MINISTRY OF ELECTRICITY & WATER WATER PROJECTS SECTOR Tender No . MEW/ 85 / 2012-2013 Construction and Maintenance of 5 Nos. R.C. Ground Reservoirs for Fresh Water, 55 M.I.G Capacity Each, and Annexed Works at Mutla High (Stage-II)	وزارة الكهرباء والماء قطاع مشاريع المياه مناقصة رقم و ك م / 85 /2012-2013 انشاء وانجاز وصيانة عدد 5 خزانات أرضية من الخرسانة المسلحة للمياه العذبة سعة كل منها 55 مليون جالون إمبراطوري مع الاعمال الملحقة بمنطقة المطلاع العالي (المرحلة الثانية)

الجزء الرابع : الشروط والإجراءات الخاصة

4

SECTION FOUR : TECHNICAL SPECIFICATIONS

MINISTRY OF ELECTRICITY AND WATER

WATER PROJECTS SECTOR

CONSTRUCTION AND MAINTENANCE OF 5 NOS. R.C. GROUND RESERVOIRS FOR FRESH WATER, 55 M.I.G CAPACITY EACH, AND ANNEXED WORKS AT MUTLA HIGH (STAGE-II)

GENERAL SPECIFICATIONS FOR PIPING WORKS

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SECTION-4A.1

GENERAL SPECIFICATIONS

CONTENTS

4A.1 GENERAL

4A.1.1 SCOPE

This Part of the Specification gives a general description of the pipe works and covers the general duties of the Contractor in connection with the administration of the Contract for **CONSTRUCTION AND MAINTENANCE OF 5 NOS. R.C. GROUND RESERVOIRS FOR FRESH WATER, 55 M.I.G CAPACITY EACH, AND ANNEXED WORKS AT MUTLA HIGH (STAGE-II)**.

Also forming part of the works is preparation of final designs, construction and shop drawings, as built (record) drawings and Operation and Maintenance manuals. The tender scope of procurement shall include any of the material or equipment entailed required to complete the project. The project shall be done in remeasurement basis.

The contractor shall provide all necessary supervision, engineering and technical expertise, final design, obtain approvals and provide all necessary temporary and permanent facilities, materials, labour, construction equipment and temporary works and undertake everything necessary to complete the Works.

4A.1.2 INFORMATION PROVIDED BY THE EMPLOYER

Geological, climate, survey information and any details of existing structures or services provided in the Contract or otherwise provided by the Employer are provided in good faith to assist the Contractor in the preparation of his tender and the execution of the Contract. Provision of information shall not release the Contractor of any of his responsibilities under the Contract in particular the Contractor’s obligations to make such independent enquiries and surveys to ascertain the full nature of the Works as required by the Contract. The information is not warranted by the Employer nor the Engineer and the Contractor shall only make use of and interpret the information on his own responsibility.

4A.1.2.1 Geotechnical Information

The Contractor shall carry out ground and sub-soil investigation for above mentioned scope of work.

4A.1.2.2 Survey Data

Details and locations of temporary survey monuments are shown on the Drawings. The Employer offers no warranty as to the accuracy of the monuments nor to their existence at the time of Contract.

4A.1.3 UNITS AND ABBREVIATIONS

Units used in the Contract shall be the metric international system of units (SI units) according to the British Standards Institution publication PD 5686 `The use of SI units' except where otherwise stated.

The units and abbreviations used in the documents are listed in Section 6 to this Section of the Specification

4A.1.4 CONTRACTOR'S ORGANISATION

4A.1.4.1 Project Management

The Contractor shall be responsible for administration of the Contract from the award of Contract through design (to the extent required under the Contract), obtaining approvals, procurement, manufacture, works testing, delivery of materials to Site, installation, testing and commissioning.

Designs, drawings and documents submitted to the Engineer for approval shall only be considered as bonafide submissions by the Engineer if they have been signed, stamped and dated by the Project Manager. The Project Manager or his approved assistant shall have checked the design, drawing or document, whether initiated by the Contractor himself of by one of his Sub-contractors.

4A.1.5 MATERIALS AND STANDARDS

4A.1.5.1 Materials General

Materials means all materials, goods and articles of every kind whether natural, raw, processed or manufactured and equipment and plant of every kind for incorporation in the Works.

All materials shall be new and of the kinds and qualities described in the Contract and shall be at least equal to any approved samples.

Materials shall be transported, handled and stored in such a manner as to prevent deterioration, damage or contamination.

Where the Contract requires the Contractor to submit samples or the names of proposed suppliers of materials, the Contractor shall submit samples and details from three different acceptable sources. The Engineer will select and notify his approval to one of the suppliers.

4A.1.5.2 Materials in Contact with Water

Substances and products used in the Works which may be applied to or introduced into water which is to be supplied for drinking, washing or cooking or for food production shall not contain any matter which could impart taste, odour, colour or toxicity to the water or otherwise be objectionable on health grounds. Only those substances and products which meet the requirements of Regulation 25 of the Water Supply (Water Quality) Regulations 1989 (Statutory Instrument No 1147, HMSO London ISBN 0110971477) shall be used in such situations.

4A.1.5.3 Materials provided by Employer

The Employer will supply ductile iron pipes & valves, required for the Contract as per bill of quantities. The Contractor shall collect these items from the Employer's storage areas located at Subhan.

At the commencement of the Contract and prior to placing orders for materials, the Contractor shall inspect the store records and materials and shall confirm with the Engineer the actual availability of pipework, fittings, valves and accessories available for issue to the Contractor from the Employer's store, giving due regard to the required

pressure ratings and shall determine the quantities of materials that need to be procured by the Contractor.

The Contractor shall list the materials he intends to remove from the storage area each time items are removed and shall obtain the Engineer's approval prior to removal. The list shall be signed by both the Employer's storekeeper and the Contractor at the time of hand over. A copy of the signed list shall be submitted to the Engineer together with a certificate listing the materials which have been taken over by the Contractor and identifying any items that have been rejected.

The Contractor shall inspect and accept the materials in the Employers store and shall thereafter take responsibility for the accepted materials. Once any pipework and valves have been accepted by the Contractor they shall be deemed to have been taken over by the Contractor and they shall be Insured by the Contractor as part of the Works. Any subsequent damage or loss shall be the responsibility of the Contractor

Any damage caused by the Contractor to materials in the Employer's store shall be made good by repair or replacement by the Contractor as approved by the Engineer.

If the Contractor considers any materials to be damaged or unsuitable for use in the Works, he shall immediately inform the Engineer who will agree whether the materials shall be rejected. If necessary the Engineer shall arrange for inspection of the materials by the Supplier. Rejected materials shall be removed by the Contractor to a separate quarantine storage area to be agreed with the Engineer.

The Contractor shall give the Engineer at least 24 hours notice of all inspections and collections of materials from the Employer's storage areas.

4A.1.5.4 Materials to be provided by Contractor

Other than the materials provided by the Employer the Contractor shall supply all materials like Ductile iron pipes, MOV, Flow meter, fittings etc..necessary to complete the Works as per bill of quantity.

The Contractor shall ensure that all materials supplied under the Contract are compatible in every respect with the materials supplied by the Employer.

The Contractor shall give due regard to any change in specified pressure rating and flange ratings along the length of the pipeline.

4A.1.5.5 Surplus Materials

Upon completion of the Works or whenever ordered by the Engineer the Contractor shall collect up from the Site any materials provided by the Employer which are surplus to requirements and shall transport, off-load and make necessary repair hand them over to the Employer at the Employer's store, Subhan.

4A.1.5.6 Special Tools and Lifting Tackle

Any special jointing tackle loaned by the Employer or his suppliers may be used by the Contractor but shall be returned in good order upon completion of the Works.

Materials and tackle which have been broken damaged or lost during the course of the Works shall be replaced by the Contractor, failing which the Employer shall be entitled to deduct the cost thereof from monies due to the Contractor.

4A.1.5.7 Reference Standards

Reference Standard means an authoritive recognised international standard such as those published by the British Standards Institution.

Unless otherwise specified all materials, workmanship and products shall comply with the relevant Reference Standard.

Unless otherwise specified Reference Standards shall be the latest edition of American or British standards as stated within the specification clauses. Where no Reference Standard is specified the Contractor shall propose a standard for the Engineer's approval.

The latest edition shall mean the edition current three months before the date for submission of Tenders.

The Contractor may propose, at no extra cost to the Employer, the use of an alternative equivalent internationally recognised Reference Standard.

Alternative equivalent standards proposed by the Contractor shall be no less exacting, in the opinion of the Engineer, than the specified standard.

Where the Contractor proposes an alternative standard he shall submit to the Engineer for approval two original copies of the proposed standard along with an authenticated translation in English of the standard he proposes. The Contractor shall demonstrate to the Engineer that the alternative standard is suitable and equivalent to the specified standard and shall provide proof of previous successful use of the proposed standard.

Where no appropriate standard exists, as for example in the case of patents or special materials, details of the proposed process and materials together with all supporting data shall be submitted to the Engineer for approval.

A list of certain Standards referred to in the Contract is included in respective technical specifications. Before commencing the Works the Contractor shall supply to the Engineer one complete set of the listed Standards.

4A.1.6 SUBMITTAL PROCEDURES

4A.1.6.1 Document submissions by the Contractor

Each design, drawing or document shall be clearly identified as to their location in, or application to, the Works and shall be stamped, checked, signed and dated by the Project Manager prior to submission.

All submissions shall be made under the cover of a transmittal note one copy of which will be signed by the Engineer and returned to the Contractor.

Submittals shall be made in accordance with an approved programme which shall have been submitted to and approved by the Engineer.

4A.1.6.2 Drawings

The Contractor shall submit detailed drawings of the Works including shop drawings of all mechanical works, pipeline plans and sections, reinforcement drawings, shop

drawings for all valve chambers, thrust blocks and anchors, fully detailed design drawings and shop drawings for road crossings and all other such drawings and details necessary for the proper execution of the Works.

4A.1.6.2.1 Form of Drawings

All drawings shall be on ISO standard size sheets with a maximum size of A1 unless otherwise agreed by the Engineer.

Every drawing shall have a title box in the bottom right corner, in a format approved by the Engineer, showing:-

- Employer's name;
- Title of scheme;
- Title of Contract;
- Contractor's name;
- Title of work location;
- Title of drawing;
- Drawing number;
- Date;
- Author;
- Signature of Contractor’s Project Manager (to the effect that the drawing (whether his own or from any other source) has been checked by him before submission to the Engineer).

Each drawing shall have a separate revision box with space for up to 10 revisions, including revision number, date, description and signature of the checker. The drawing shall also include adequate clear space for the Engineer's markings.

Drawings shall be drawn to specified scales or to such scales as are appropriate for clearly detailing and conveying the Contractor's proposals. Scales shall generally be 1:2, 1:5, 1:10 or multiples of 10 thereof. The appropriate measuring scales used shall be shown on the drawings.

Drawings shall include cross-references where appropriate and key information such as vital levels and dimensions. All plans shall show the `north' direction.

All drawings submitted by the Contractor shall be in English and SI units.

When drawings are revised, the revision letter or number shall be incorporated in the title block and the revision shall be clearly indicated on the drawing with the revision letter or number shown in an adjacent triangle.

Prints of drawings shall show dark and fade-proof line work on a light and non-darkening background. Prints shall be on durable paper of good quality and 80gm/m^2 minimum weight. Reproducibles shall be on 75 micron durable plastic film.

The Engineer will not approve any unclear or ambiguous drawings.

4A.1.6.3 Documents

Documents shall include where appropriate:-

- Contents list;
- Scope (description of the contents and purpose of the submission);

References:- specification requirements, Standards, manuals and supporting documents used, drawing numbers, and titles of drawings.

- Criteria, parameters and methods used;
- Test procedures, analyses and results;
- Calculations and schedules;
- Qualitative description and comments on results;
- Any other relevant information;
- Appendix.

4A.1.6.4 Numbering and Titling

The Contractor shall use a numbering system for drawings and documents so that each number used is unique. The numbering system shall be used for all submittals made by the Contractor, irrespective of whether the material originates from the Contractor, from a Sub-contractors or from any other source.

The numbering and title system shall be designed so that management, transmittal, communication, storage and retrieval of drawings and documents can be carried out efficiently.

4A.1.6.5 Programme of Submissions

Submittals shall be made in accordance with an approved programme. The programme shall provide for the Engineer's review of the Contractor's submissions to be undertaken at a reasonably steady rate of working. No submittals will be accepted for review by the Engineer until the programme for their submission has been approved.

The programme shall make reasonable provision for re-submission of non-approved designs, drawings and documents and for the time needed to transmit designs, drawings and documents.

Submissions shall be made sufficiently early to allow time for review, comment, re-submission and approval by the Engineer before ordering, commencement of manufacture, installation or construction as the case may be.

4A.1.6.6 Approval

The following meanings shall apply:-

- "Preliminary" means submittals which the Contractor submits to the Engineer for approval and any submittal returned by the Engineer marked "Preliminary" or not marked "Approved".
- "Approved" means submittals which the Engineer has both marked "Approved" and returned to the Contractor. Approval in this context means that the work described thereon may proceed.

- A drawing which forms part of an approved design or document shall not be an approved drawing unless it has been marked "Approved".

Approval may be partial or conditional. Submissions may be marked "Approved in respect of ... certain parts ...." or "Approved subject to .... actions to be taken by the Contractor before the work described can proceed ...". In such cases the Contractor may carry out only the approved Works. Conditional actions shall be confirmed to the Engineer in writing before the respective Works are executed.

The Engineer may withdraw or modify his Approval as a result of subsequent submissions. In this circumstance, he will inform the Contractor in writing of the withdrawal or modification. Upon receipt of such notification of withdrawal or modification the Contractor shall immediately take the necessary actions and confirm the action taken to the Engineer in writing.

4A.1.7 CONTRACTORS DESIGN SUBMITTALS

The Contractor’s responsibilities include the final design and preparation of shop drawings for the Works. Submittals made by the Contractor shall include but shall not be limited to the following:

- Pipeline Profiles;
- Road Crossings;
- Chambers and Anchors etc..

4A.1.7.1 Pipeline Profiles

The Contractor shall prepare plans and longitudinal sections showing positions and levels of all services. He shall modify the proposals as necessary, during the course of the works, to accommodate the exact position of any service, pipe or obstruction and to satisfy any particular requirements and restrictions of the service owner.

The Contractor’s design shall comply with the design criteria specified elsewhere particularly in respect of minimum and maximum cover, minimum pipe gradients, location of air valves washouts.

4A.1.7.2 Road Crossings

The Contractor shall prepare detailed designs of all road crossings including fully detailed drawings of all proposed permanent and temporary works. The details shall include but shall not be limited to details of required working areas and site accesses, details of temporary excavations, pits, working and storage areas, detailed cross sections and longitudinal sections of the proposed crossing.

4A.1.7.3 Chambers and Anchors

The Contractor shall prepare fully detailed shop drawings of each chamber and anchor block.

The drawings shall provide:

- Detailed setting out information;
- Details of all pipe fittings including flange type, pressure ratings and exact dimensions of fittings;

- Details of chamber metalwork including access ladders, covers, ventilators, valve spindle supports and thrust restraints;
- Concrete dimensions including exact dimensions of pre cast components, tolerances and allowances;
- Tanking and waterproofing details.

4A.1.8 METHOD STATEMENTS

The Contractor shall submit detailed method statements for each construction, installation, testing and commissioning activity.

Where an activity will require connections into existing MEW works or could affect the operation of existing MEW works, method statements shall be submitted at least 28 days before commencement of the operation.

The method statement shall comprise a step by step schedule of specific operations or activities with description, dates, times and duration of each step, including details of all temporary works, labour and plant to be used. It shall include contingency plans for emergencies where appropriate and shall clearly detail responsibilities.

4A.1.9 OPERATING AND MAINTENANCE MANUALS

The Manuals shall be sub-divided into locations such as isolating valves, sluice valves and shall be divided into (a) Maintenance (b) Operation.

Information supplied by Sub-contractors and manufacturers employed by the Contractor shall be co-ordinated into the comprehensive Manual.

Cross-referencing of descriptive matter drawings must be complete.

The Operation and Maintenance Manual shall describe the installation as a whole and shall give a step-by-step procedure for any operation likely to be carried out during the life of the Works, including erection, commissioning, testing, operation, maintenance, dismantling and repair.

The Manual shall identify and cover aspects liable to affect other installations and shall include all health and safety precautions to be taken.

Maintenance instructions shall include charts showing lubrication, checking, testing and replacement procedures to be carried out at daily, weekly, monthly and longer intervals to ensure trouble-free operation. Where applicable, fault location charts shall be included to facilitate tracing the cause of malfunction or breakdown.

All drawings incorporated in the manuals shall be presented in such a way that they can be easily referred to whilst reading the associated description in the text.

The manual shall be in the English language. Each volume shall be numbered in sequence. Pages shall be of A4 size to ISO 216 or folded to that size and placed in a loose leaf four ring hardcover binder, using not more than 70% of the binder capacity.

The cover of each volume shall have inscribed on it, the names of the Employer, contract and the subject matter. A contents page shall be inserted in each volume and index tab pages shall be provided to permit quick reference.

Any additions, alterations or deletions required by the Engineer shall be incorporated.

Ten final copies shall be submitted not later than three months before the end of the Maintenance Period.

4A.1.10 RECORD DRAWINGS (AS BUILT DRAWINGS)

The Contractor shall provide true to scale record drawings of the whole Works "as constructed" within thirty days of the Certificate of Completion for the Works.

Record drawings shall be to a format approved by the Engineer and shall include one set of reproducible. Record drawings shall include, but not be limited to:-

i) Structure drawings;

ii) Pipeline plans, profiles and cross sections, annotated to indicate soil types encountered during excavations and using MEW standard signs, symbols and abbreviations;

iii) Reinforcement details for all structures;

iv) The positions and extent of all sheeting and like constructional and temporary works left in any excavations;

v) Exact locations of all services encountered during construction;

vi) Chamber drawings showing pipework, connections and fittings, etc.;

(This Clause should be read in conjunction of Section 3.)

4A.1.11 PROGRAMME AND PROGRESS

4A.1.11.1 Monthly Progress Reports

The Contractor shall prepare and submit to the Engineer in ten (10) copies monthly progress reports showing the actual and programmed progress of the Works. The report shall be submitted no later than the third day of the following month.

The report shall be in narrative form supplemented by photographs, tables and charts and programmes.

The report shall describe the activities of the Contractor including:-

- Work done during the month;
- Problems encountered, including past problems still unresolved;
- Expected progress during the next month;
- Cash flow forecast and status of interim payments;
- Status of outstanding items;
- Photographs showing project progress (minimum 20 No.);
- Equipment on site and its utilisation;
- Staff assignments;
- Manpower employed.

4A.1.11.2 Monthly Progress Review Meetings

The Engineer will establish the requirement for regular progress meetings. These meetings will be scheduled at a time convenient to the Engineer's Representative, Engineer, Employer and the Contractor.

A written agenda will be prepared by the Engineer for each meeting and copies sent to the Employer and the Contractor in advance. Generally, the format will allow for discussion on the following:-

- Progress;
- Current problems;
- Past problems still unresolved;
- Anticipated problems.
- The Engineer will summarise the discussions at this meeting identifying responsibility for follow up action.

4A.1.11.3 Records

The Contractor shall submit weekly records to the Engineer in a format approved by the Engineer detailing the status of permanent materials, records of construction and details of the Contractors temporary facilities plant and labour.

Material records

The Contractor shall keep detailed and up-to-date records of all materials showing the quantities of each type, size and class that have been:

- Requested from the Employer's stores;
- Received from the Employer's stores;
- Returned to the Employer's store;
- Ordered during the course of the Works;
- Delivered during the course of the Works;
- Found to be faulty, damaged or deficient;
- Broken, damaged or lost during the course of the Works;
- Repaired;
- The records shall assign a unique reference number to each major item such as pipe length, and shall record the 'as built' location and date of installation;
- Pipe materials shall be sub divided into pressure classes;
- The Contractor shall submit up-to-date copies of the records to the Engineer at weekly intervals;

Pipe laying Records:

The Contractor shall maintain detailed and up-to-date records in a form to be approved by the Engineer of the following:

- Any deviations of the pipeline line and level from that shown on the Drawings;
- Installed details and locations of all structures, fittings, valves, joints and the like;
- Details of any water encountered in excavations;
- Details and locations of any pipe fittings installed for the purposes of pipeline testing, swabbing and disinfection;
- Details and locations of all cable draw pits;

4A.1.12 THE SITE

4A.1.12.1 Location

The Site generally consists of area as shown in the General Layout & proposed reservoirs location is adjacent to existing W.D.C. known as Mutla High Water Distribution Complex.

4A.1.12.2 Access to Site

Except as may be otherwise provided in the Contract the Contractor shall arrange for, construct, maintain, remove and reinstate all temporary site roads and accesses required for and in connection with the execution of the Works. All such roads and accesses shall be subject to the approval of the Engineer.

Where the proposed access is across land not owned or occupied by the Employer the Contractor shall, at his own expense, obtain approval to the access from the Owners and shall provide the Engineer with a copy of the approval.

4A.1.12.3 Temporary Working Areas

As soon as practicable after Commencement of the Works and having regard to the programme, the Contractor shall propose his own temporary working areas and submit plans of these areas, together with an assessment of the period of time during which he will occupy them, to the Engineer for approval and for the subsequent approval by the Municipality.

4A.1.12.4 Temporary Fencing

The Contractor shall fence all temporary working areas, storage areas and accommodation areas and shall ensure the areas are kept tidy and secure at all times.

4A.1.12.5 Reinstatement of the Site (including all temporary areas)

Before entry onto any area of the Site (including all temporary areas, working areas and access routes) the Contractor shall make a record, to be agreed by the Engineer, of the conditions of the surfaces. On completion the Contractor shall reinstate the areas and all land and property affected by the Works to the standards specified in the Contract which shall be at least equal to that existing at the commencement of the Works. Reinstatement shall be undertaken as soon as possible after the work in the areas has been completed.

4A.1.12.6 Maintenance of Access

The Contractor shall ensure that adequate access is maintained at all times to properties and facilities affected by the Works.

4A.1.13 SURVEY AND SETTING OUT

4A.1.13.1 Position of Works

The Works are shown on the drawings but the precise position lines and direction of the works are not necessarily indicated and shall be determined by the Contractor and detailed in shop Drawings as the Contract proceeds.

The Contractor shall be responsible for the preparation of all setting out information in accordance with the Drawings and shall be responsible for the correct accurate setting out of the Works.

4A.1.13.2 Levels

The Contractor shall establish construct and protect benchmarks as necessary during the period of construction and such benchmarks shall be checked periodically and whenever required. On completion of the works they shall be left as permanent benchmarks.

Unless otherwise agreed by the Engineer benchmarks shall be marked on permanent structures. The Contractor shall obtain prior approval from owners for the establishment of benchmarks on privately owned property.

4A.1.13.3 Datum

The datum for all levelling on the Site shall be the Kuwait Public Works Datum or such other Datum as the Engineer may from time to time designate or approve in writing.

The locations and levels of existing benchmarks in the vicinity of the works shall be obtained from the appropriate Government department with the co-operation of the Engineer.

4A.1.13.4 Co-ordinates

All setting out co-ordinates are to Kuwait Transfer Mercator (KTM).

4A.1.14 GENERAL REQUIREMENTS

4A.1.14.1 Amenities to be preserved

The Contractor shall cause the least possible interference with existing amenities, whether natural or man-made. No trees or bushes shall be cut down or felled except with the express written approval of the Engineer.

No fencing shall be removed without the approval of the Engineer. Any fencing removed shall be reinstated as soon as practical after completion of work in the area. The reinstated fencing shall be at least equal to that removed.

4A.1.14.2 Co-operation at Site

All work shall be carried out in such a way as to allow access and afford all reasonable facilities for any other Contractor and his workmen and for the workmen of the Employer and any other person who may be employed in the execution and /or operation at or near the Site.

The Contractor shall use his best endeavours to co-operate with such other Contractors and their personnel without interfering with them and shall observe all the instructions and orders of the Engineer in that connection.

On no account shall valves or other controls on the existing system or new works by other Contractors be operated for any purpose by the Contractor.

In the preparation of his programme of work the Contractor shall at all times take full account of and co-ordinate with the programming of the work of other Contractors.

4A.1.14.3 Roads

The Contractor shall take all reasonable precautions to ensure that roads and thoroughfares used by him either for the construction of the Works or for the transport of plant labour and materials are kept clean. If in the opinion of the Engineer the roads are not kept clean the Contractor shall take all necessary and immediate steps to clean them.

The Contractor shall ensure that damage to any public or private roads, footpaths and tracks used by any of his vehicles or plant shall be kept to a minimum and he shall be responsible for the cost of all repairs necessary to restore any road, track or footpath to the approval of the Engineer.

4A.1.14.4 Site to be Kept Clean

Every part of the Site shall be kept clean during construction of the Works and shall be thoroughly cleaned upon completion.

The Contractor shall clear away all debris and surplus materials as the work proceeds. On completion of work in any area the Contractor shall remove all materials and leave the Site in the condition it was prior to commencing the works, or as directed by the Engineer.

4A.1.14.5 Dust Control

The Contractor shall, to the maximum extent possible, prevent nuisance due to dust raised as a result of delivery of materials, excavation, backfilling, stockpiling, loading or unloading and hauling. Dust control shall be by watering by tanker trucks with spray attachments or by other approved methods.

4A.1.14.6 Disposal of Surplus Excavated Material

Except where otherwise provided in the Contract, all surplus excavated material and debris arising from the Works shall be disposed of daily at places approved by the Municipality and the Engineer. The Contractor shall be solely responsible for the disposal of material and he shall indemnify the Employer against any claims arising from unauthorised disposal of materials. The Contractor shall bear the costs, including all penalties, of removing any offending material to an authorised disposal area and making good any damage caused.

The Contractor shall ensure that each cartage Contractor and lorry driver employed for the disposal of materials is given written instructions as to the approved place where each load is to be tipped.

The Contractor shall retain in his office copies of each instruction, together with a list of approved disposal areas, for inspection at any time by the Engineer.

4A.1.14.7 Works to be kept clear of Water

The Contractor shall construct all permanent works in the dry.

He shall provide and operate pumping plant and dewatering equipment and construct any temporary drains, water courses and other works that may be required to divert water away from the works and to keep excavations dry.

The Contractor shall ensure there is no risk of any part of the Works floating.

The Contractor shall, before commencing any excavation, obtain the Engineer's approval to his proposals for dealing with water. Once installed Temporary Works and plant shall not be removed without the approval of the Engineer.

4A.1.14.8 Disposal of Water

Water removed from the Works must not be allowed to cause nuisance or damage to property or service.

The Contractor shall arrange for disposing of any water from the Works and shall comply with any requirement of the owners of watercourses, sewers or storm water drains into which the water is discharged.

The Contractor shall take all necessary precautions to prevent the discharge of oil, sediment and toxic materials into any watercourses, sewers or storm water drain.

The Contractor shall provide and maintain to the approval of the Engineer efficient settling basins, sand traps and oil traps as the Engineer deems necessary.

The Contractor shall be held responsible for any damage which occurs as a result of any discharges into watercourses, sewers, or storm water drains and shall pay the cost of repairing any damage including any penalties.

4A.1.14.9 Suppression of Noise

The Contractor shall endeavour, both by means of temporary works and by the use of appropriate plant or silencing devices, to ensure that the level of noise resulting from the execution of the Works does not constitute a nuisance.

4A.1.14.10 Water Supply

The Contractor shall arrange for the supply of water for the purposes of the Contract. The water shall be of potable quality. Where water cannot be made available direct to the Site through the Employer’s mains the Contractor shall arrange at his own expense for the conveyance of a bulk supply of water to the Site and shall ensure that sufficient water is available at all times to ensure continuity of work.

4A.1.14.11 Lighting and Electric Power

The Contractor shall provide and maintain efficient temporary lighting and power supplies for all parts of the Works as may be necessary and shall, in connection with such supplies, adopt precautions to ensure the safety of all personnel.

All lighting and power supplies shall be installed in accordance with the Ministry of Electricity & Water Regulations for Electrical Installations.

The Contractor shall provide portable tools, handlamps and the like which shall be used with circulating current earth monitoring or earth leakage circuit breakers. All hand-held electric power tools should conform to BS 2769 and shall be either earthed or "double insulated". All plugs and sockets should conform to BS EN 60309-2. If a

transformer is used, it shall be to BS 3535 and shall be centre tapped to earth. All electric tools shall be carefully inspected before use for signs of faults in wiring switching guards etc. Maintenance should be carried out on a regular basis by a competent mechanic or electrician. A register shall be kept of all such maintenance.

The Contractor shall provide adequate lighting for the proper execution and inspection of the Works. If the Engineer considers the intensity of lighting to be inadequate for the proper execution and inspection of the work being undertaken the Contractor shall install such additional lighting as the Engineer may require.

Any permanent fencing or other safeguards requiring erection around electrical equipment shall be completed as far as practicable before connection is made to the electricity supply. In so far as this is not practicable the Engineer may permit the use of temporary fencing or other safeguards.

Where work has to be carried out in proximity to operational mechanical and electrical equipment other than the Contractor's own plant, the Contractor shall put into operation a "Permit to Work" system to the approval of the Engineer.

4A.1.14.12 Sanitation

The Contractor shall maintain the Site and all working areas in hygienic conditions and in all matters of health and sanitation shall comply with the requirements of the local Medical Officer of Health or other competent authority.

4A.1.14.12.1 Sanitary Conveniences

The Contractor shall throughout the Contract provide maintain and cleanse water closets to the approval of the Engineer and shall ensure that his employees do not foul the Site but properly make use of the conveniences.

The Contractor shall make all arrangements for the proper discharge of sewage and drainage from or in connection with the work and shall maintain the arrangements to the approval of the Engineer and the Authority concerned for as long as they may be required.

The Contractor shall also make the conveniences available to other persons on the Site.

4A.1.14.13 Method of Working

The Contractor shall adopt methods of working that result in the satisfactory completion of the Works to programme and limit any disturbance and damage to a minimum.

Constructional plant used in the execution of the Works shall be of an appropriate design and shall be used in a manner approved by the Engineer.

The Engineer may at any time withdraw approval and the Contractor shall immediately adopt another method of working. The Contractor shall have no claim against the Employer for costs incurred by him in changing the method of working or in the provision and use of other plant.

4A.1.14.14 Protection of the Works from the Weather

The Contractor shall protect all work and materials from deterioration or damage by weather or climatic conditions, dust and the naturally aggressive nature of the soil.

4A.1.14.15 Video Record

Throughout the Contract, the Contractor shall make video recordings of manufacturing, installation, construction and testing of the Works. One copy of all recordings shall be supplied to the Engineer.

On completion of the Contract, the Contractor shall provide two video tapes of 45 minutes duration showing the implementation of the Contract in a clear logical sequence of the main technical aspects of the Contract. The two tapes shall each have an explanatory sound track, one in Arabic and one in English.

The Contractor shall employ a specialist company to make the video recordings and to produce the 45 minute video tapes. The Contractor shall obtain the Employer's approval to the specialist company and the copy of the film.

4A.1.14.16 Photographs

The Contractor shall provide photographs at monthly intervals and additionally as ordered by the Engineer and shall provide from each negative two colour prints on glossy paper unmounted and of a size not less than 120mm x 180mm.

Each print shall be identified on the back with the Contract number, the date and place of taking and such other information as may be relevant.

The Contractor may also take record photographs for his own purposes, but shall ensure that no use is made of any negative or print for purposes not directly related to the Contract without permission from the Employer.

The Contractor shall ensure that no unauthorised photography is allowed on the Site.

All photographs shall be clear, in focus and properly exposed and printed. The film size shall be not smaller than 35 millimetres.

4A.1.15 SAFETY AND SECURITY

4A.1.15.1 Safety General

The Contractor shall ensure that the Works including all temporary works are safe.

The Contractor shall ensure that his own staff and the staff of his suppliers and Sub-Contractors adopt safe methods of working and shall ensure the duties of those who design manufacture import or supply any part of the Works or articles in connection therewith are fulfilled in respect of any safety regulations imposed by law or by any authorised body empowered to make such regulations.

The Engineer shall be notified by the Contractor immediately any accident occurs whether on Site or off Site in which the Contractor is directly or indirectly involved which results in any injury to any person whether directly concerned with the Site or whether a third party. Such initial notification may be verbal and shall be followed by a written comprehensive report within twenty-four hours of the accident.

4A.1.15.2 Transport

Transportation of any material by the Contractor shall be in suitable vehicles which when loaded do not cause spillage and all loads shall be suitably secured. Any vehicle which does not comply with this requirement or any of the local traffic regulations and laws shall be removed from the Site.

4A.1.15.3 Inspection

The Contractor shall provide all necessary facilities for the safe inspection and measurement of the Works.

Neither the Engineer nor his staff shall inspect any part of the works that is deemed by the Engineer to be unsafe. The Engineer shall not measure for payment any part of the Works that cannot be inspected.

4A.1.15.4 Safety Precautions – Noxious Gases

Where noxious gases such as Chlorine, Carbon Dioxide and the like are to be provided or already exist on the Site the Contractor shall ensure that his workpeople are advised of the associated dangers. The Contractor shall erect notices warning of the dangers in locations and of a material, size, lettering type and mounting approved by the Engineer.

4A.1.15.5 Fire Prevention

The Contractor shall not dispose of rubbish and debris by burning and shall not light fires on the Site.

The Contractor shall provide adequate fire prevention and fire fighting systems for the protection of the Works from fire and for the protection of any adjacent property which could be affected by a fire on the Site. The arrangements shall be to the approval of the Engineer.

The Contractor shall give the Fire Authority access to the Site and all facilities to inspect the fire fighting and prevention arrangements.

The Contractor shall construct, equip and administer fire points in such positions and of such size as will provide an adequate service for the protection against fire of all buildings, stores and property. He shall install and maintain a proper fire warning system.

Care shall be exercised in the operation of welding equipment, oxy-acetylene cutting equipment and other processes involving the use of naked flames.

Safe secure storage shall be provided for the storage of flammable liquids.

Rubbish and surplus material of a flammable nature shall be removed daily.

4A.1.15.6 Security of the Works

The Contractor shall provide sufficient security watchmen to ensure the safety and security of the Works.

The Contractor shall secure the Works with adequately supported temporary fences

All excavations shall be adequately lit at night complete with hazard warning lights to both pedestrians and traffic, all in accordance with applicable Traffic Police Regulations.

Any unfenced opening, places where fencing is impracticable and any surface obstructions shall be attended by day and by night and shall be adequately lit at night.

All security arrangements shall be to the approval of the Engineer.

4A.1.16 ROADS

4A.1.16.1 Location of Buried Services and Obstructions

The Contractor will encounter existing services during the course of the construction of the Works.

Approximate locations of known services at the time of Tender are shown on the Drawings.

The Contractor shall confirm the details and obtained further details from the various Authorities.

Service information shown on the Drawings and any additional information provided is indicative only and no warranty shall be given or implied by the Employer, the Engineer or the respective Authority as to the accuracy or completeness of the information. It shall be the Contractor's responsibility to determine by trial holes and site investigations the exact location of all services. The Contractor shall be responsible for any costs arising from any damage to services. The Contractor shall not be entitled to any claim in respect of working around, under or supporting or diverting any service.

The Contractor shall not be entitled to any claim for additional costs, delay or disruption in any connection with dealing with services.

4A.1.16.2 Work in the Vicinity of Services

After obtaining all service records the Contractor shall conduct investigations and hand excavate trial pits to locate the exact positions of all services on the alignment of the Works.

All exposed services shall be properly protected and supported and work within the vicinity of services shall be executed so as not to cause any damage to the service all to the approval of the Engineer and the respective authority.

Any damage caused shall be immediately reported to the Engineer and the respective Authority.

The Contractor shall comply with the directions and instructions of the respective Authority in respect of repair to any damaged service.

If the Authority elects to repair damage or provide permanent support, the Contractor shall make all necessary arrangements including the provision of all reasonable access and assistance as required by the Authority and shall reimburse the Authority the charge incurred in performing the work. If the Authority requests the Contractor to repair the damage, or provide permanent support the repair or support shall be carried out strictly in accordance with the instructions of and to the approval of the Authority and the Engineer.

4A.1.16.3 Service Diversions

In the event that the locations or levels of any services interfere with the locations or levels of the permanent Works, the Contractor shall submit all information to the Engineer. Where possible the Contractor shall revise the working drawings to avoid the service.

In the event that the service cannot be avoided the Contractor shall so inform the Engineer and shall propose a suitable solution in consultation with the Authority concerned.

4A.1.17 SAMPLES AND TESTING

4A.1.17.1 Samples

Samples shall be submitted not less than thirty calendar days prior to the time that the materials represented by the samples are needed for incorporation into any work.

The material represented by a sample shall not be manufactured, delivered to the site or incorporated into any work without the approval of the Engineer.

4A.1.17.2 Storage of Approved Samples

Samples after approval by the Engineer shall be carefully preserved and stored to the approval of the Engineer for use as reference samples.

Samples shall not be disposed of until permission is given by the Engineer.

4A.1.17.3 Manufacturers' and Contractor's Certificates

Test Certificates required by the Specification or relevant Reference Standard shall be clearly identified by serial or reference numbers and shall include any information required by the relevant Reference Standard or Specification clause.

Test certificates shall be submitted as follows:

Manufacturer's and supplier's test certificates shall be submitted as soon as the tests have been completed and in any case not less than seven calendar days prior to the time that the materials represented by such certificates are needed for incorporation into the Works.

Certificates of test carried out during the construction or on completion of parts of the Works shall be submitted within 7 days of the completion of the test.

4A.1.18 QUALITY CONTROL PROCEDURES

4A.1.18.1 Contractor Responsible for Quality Control

In addition to any specific obligations for sampling and testing the Contractor shall be responsible for routine inspection, sampling and testing of all materials, workmanship, plant and measuring devices, in order to ensure the quality of work and to ensure that the completed work is of high quality which complies in all respects with the Specifications, approved samples and general intent of the Contract.

The Contractor shall provide all supervision, measuring and test equipment necessary to ensure the quality of the Works.

4A.1.18.2 Quality Control Engineer

The Contractor shall appoint a Quality Assurance (QA) supervisor who's sole responsibility shall be the assurance of quality.

4A.1.18.3 Reference Standards

The Contractor's quality control procedures shall take full account of all relevant quality standards, codes of practice and other criteria governing materials and workmanship required by the Contract.

4A.1.18.4 Submissions by the Contractor

Submissions to be made by the Contractor to the Engineer shall include the following:

- CV and details of the proposed QA supervisor;
- Quality control plan;
- Inspection records;
- Test certificates;
- Periodic reports;
- Inventories.

4A.1.18.5 Control Procedures Generally

The Contractor shall be responsible for establishing and maintaining procedures for quality control which will ensure that all aspects of the Works comply with the requirements of the Contract.

As soon as reasonably practicable and not more than 6 weeks after the Date of Enterprise the Contractor shall submit for approval a quality control plan giving detailed proposals for control of quality of all aspects of work on the Site and at suppliers' works.

The quality control plan shall include the following:

- A list of the Contractor's staff engaged in quality control;
- A list of any outside testing agencies employed by the Contractor for work in connection with quality control;
- A list of major items of equipment and a layout of the testing laboratory, together with details of the tests which will be carried out there;
- A list of manufactured items and materials, to be obtained by the Contractor for the Works, which require inspection at the suppliers' premises, and the proposed procedures for ensuring quality control is carried out;
- A list of materials and operations to be inspected by the Contractor at the various stages of construction work on Site, together with inspection procedures, test types and frequencies;
- Samples of proposed quality control records, testing forms and reporting forms;
- A list of proposed 'hold points' defined as points at which specified inspection and documentation shall be performed by the Contractor and reviewed by the

Engineer prior to proceeding (e.g. soil testing, concrete placement, pipeline testing, setting out, etc.).

Unless the Engineer permits otherwise, the approved quality control plan shall be followed throughout the construction of the Works. Should the Engineer be dissatisfied with the Contractor's Quality Control Plan at any time the Contractor shall alter his Plan as necessary.

4A.1.18.6 Samples etc. to be provided

The Contractor shall provide all samples for testing, consumable materials used in testing procedures and all test equipment, storage, packing, and transport required in connection with quality control.

4A.1.18.7 Inspections and Tests

The Contractor shall be responsible for ensuring that all inspections and tests in connection with quality control or otherwise are properly carried out whether on the Site or elsewhere and that where necessary the appropriate remedial measures are taken.

Plant and materials to be tested and inspected at a manufacturer’s factory shall be inspected and witnessed by the Engineer or an independent organisation, appointed by the Employer.

The Contractor shall ensure that access to Suppliers premises is available to the Engineer or his representatives throughout the Contract period and shall, at no additional cost, provide any facilities and equipment required by the Engineer to carry out inspection at any time during the Contract period.

Satisfactory testing or inspection of manufactured items or materials shall not relieve the Contractor of his responsibility to ensure that manufactured items and materials comply with the Contract when they are incorporated in the Works. Manufactured items and materials delivered to the Site shall be inspected on arrival and any defects shall be notified to the Engineer. Rectification of any defects, either at the site or at the manufacturers premises, or replacement of defective items shall be to the approval of the Engineer.

4A.1.18.8 Site Records and Test Certificates

Daily records of on-site testing and inspection shall be kept on forms of approved format. Test results shall be certified by the Contractor's Quality Control Engineer. All test certificates and inspection records (including any from suppliers or other outside testing agencies) shall be clearly identified with the appropriate part of the Works to which they refer, and shall include information required by the relevant Reference Standard or Specification clauses. All such records and test certificates shall be submitted to the Engineer.

The timing for submission of certificates shall be as follows:

- Manufacturer's and supplier's test certificates shall be submitted as soon as the tests have been completed and in any case not less than fourteen (14) days

prior to the time that the materials represented by such certificates are needed for incorporation into the Permanent Works;

- Certificates of tests carried out during the construction or on completion of parts of the Permanent Works shall be submitted within seven days of the completion of the test.

4A.1.18.9 Periodic Reports

Once each week, or at such longer intervals as the Engineer may allow, the Contractor shall submit in an approved form information on all quality control inspections and tests performed at Site and elsewhere in the intervening period.

The report shall include all work performed by the Contractor, tests performed with applicable sample numbers and inspection reports for both the suppliers premises and the Permanent Works.

Test results shall be summarised in tabular form or graphically or both in a way which best illustrates the trends, specific results and specification requirements. Where the tests show that the specified requirements were not achieved, the report shall describe the action which was taken. (For example: rejection of the work, retest, etc.)

Each report shall also contain a forecast of quality control work likely to be carried out during the period to be covered by the succeeding report. Hold points shall be identified.

4A.1.18.10 Inventories

The Contractor shall keep detailed and up-to-date inventories in an approved form of goods and materials subject to quality control which are on order, delivered, found faulty, lost during the work or to be surplus to requirements. The Engineer shall have access to these records at all times.

4A.1.19 SITE FACILITIES

4A.1.19.1 Employers Requirements

For the purposes of the Contract the Contractor shall provide and maintain accommodation, offices, laboratory and sanitary facilities.

Prior to acceptance of any facility the Engineer shall inspect it and, if he is satisfied that the item is in compliance with the Specification, he shall issue a letter of acceptance.

When instructed in writing by the Engineer, the Contractor shall remove each office from the site and relocate as suggested.

If the Contractor fails to supply any facility within the time period specified the Employer may obtain the item or service from another party.

Unless otherwise specified or instructed by the Engineer the Contractor shall provide and maintain all of the specified items and services up to the date of the issue of the Certificate of Completion.

Before providing any item the Contractor shall submit details including drawings and specifications for the approval of the Engineer before installation. Any component or

material which becomes unsuitable or proves unsuitable shall be promptly replaced by the Contractor at the Contractor's expense.

Unless otherwise specified ownership of all items provided by the Contractor shall revert to the Contractor at the end of the Contract.

Everything provided by the Contractor in compliance with this Specification shall be deemed to be part of the Temporary Works or of the Construction Plant (whether it is owned by or is on hire to the Contractor) and the permission of the Engineer for removal from the Site may be withheld until the issue of the Maintenance Certificate.

These preparations that the contractor is obliged to supply is for his own use in applying his duty. Which is the subject of this tender, and remains in his custody till the end on the contract execution period when he has to return them.

4A.1.19.2 Engineer’s Site Laboratory

Refer section 4B.6-6

4A.1.19.3 Waste Water Disposal

Where possible wastewater shall be disposed to the public sewers otherwise disposal shall be underground via septic tanks and leach fields. The contractor shall design the wastewater disposal systems and shall submit all details and supporting calculations to the Engineer for approval.

The Contractor shall perform percolation tests at the location of each leach field. The size of the leach field or pit will be subject to the results of these tests and the approval of the Engineer. Septic tanks shall be equipped with proper inlet baffles and sealed access hatch. The size shall be sufficient to operate for at least one year without the solids overflowing into the leach fields. The leach fields or pits shall penetrate through the gatch layer if there is one. The Contractor shall submit full details of the proposed system for the approval of the Engineer.

4A.1.19.4 Water Supplies

The Contractor shall arrange for the installation and shall ensure that an uninterrupted adequate potable water supply is available to all of the Employer’s offices throughout the duration of the Contract.

4A.1.19.5 Electricity Supplies

Refer section 4B.3-4

GENERAL SPECIFICATION

APPENDIX 1 - WATER QUALITY DATA

The quality of the distilled, brackish and fresh waters is given in the following table:

Projected Water Quality of Source and Blended Waters

	Distilled water after re-carbonation	**Brackish water**	**Blended fresh water**
Temperature °C	48	-	48
Total dissolved solids	84	5230	400
pH value	8.00	7.5	7.95
Equilibrium pH value	7.84	7.56	7.66
Langelier Index (pH - pHs)	0.16	-0.06	0.29
Sodium (Na)	5	805	54
Potassium (K)	0	18	1.1
Calcium (Ca)	28	588	62.4
Magnesium (Mg)	0	172	10.6
Chloride (Cl)	7.7	1845	120
Sulphate (SO_4)	0	1302	80
Bicarbonate (HCO_3)	85.37	113	87
Nitrate (NO_3)	0	64	3.9
Alkalinity ($CaCO_3$)	70	93	71.4
Hardness (CaCO3)	70	2177	199

Notes:

i) Composition of blend based upon ratio of 7.54 migd brackish water and 115.2 migd carbonated distilled water.

ii) *Chemical results in mg/litre*

GENERAL SPECIFICATION

APPENDIX 2 - CLIMATE DATA

CLIMATE DATA

Total Annual Rainfall (mm)

Meteorological Department – Climatological Division, has provided the following information for the period 1958 to 1999.

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	TOTAL	MAX	MIN
1958	14.9	0.8	11.1	0.3	2.1	0.5					19.3	52.9	101.9	52.9	0.3
1959	39.1	15.8	8.7	9.0	4.8						10.9	27.5	115.8	39.1	4.8
1960	12.1	1.8	11.4	4.2							9.9	0.7	40.1	12.1	0.7
1961	19.4	21.1	50.5	56.4							45.9	18.0	211.3	56.4	18.0
1962	27.2	3.3	5.7	15.1	T						18.2	10.9	80.4	27.2	3.3
1963	0.2	24.1	0.4	16.3	17.6					T	8.1	0.5	67.2	24.1	0.2
1964	15.2	3.1	1.0	0.2	T					T	0.4	11.4	31.3	15.2	0.2
1965	63.0	T	5.0	3.0	4.4				T	5.4	7.6	T	88.4	63.0	3.0
1966	14.3	27.6	9.3	3.5	T					T		6.0	60.7	27.6	3.5
1967	18.5	21.1	0.9	3.2	19.0					T	107.6	0.2	170.5	107.6	0.2
1968	0.7	14.7	5.4	20.2	13.6					0.2	11.4	13.2	79.4	20.2	0.2
1969	38.6	11.4	2.5	35.7	3.4					12.9	1.2	T	105.7	38.6	1.2
1970	36.3	4.3	1.9	2.9	T						1.4	33.8	80.6	36.3	1.4
1971	13.8	11.6	11.3	53.9	2.4					T	10.9	10.0	113.9	53.9	2.4
1972	73.2	8.5	33.6	67.0	0.8	T					17.1	18.7	218.9	73.2	0.8
1973	0.6	0.8	1.7	0.8	T						T	30.9	34.8	30.9	0.6
1974	48.9	21.2	38.6	0.3	0.1					1.4		57.9	168.4	57.9	0.1
1975	29.2	21.0	4.1	46.6	11.0						3.0	25.6	140.5	46.6	3.0
1976	40.1	95.9	18.9	61.8	14.9					0.6	1.2	9.0	242.4	95.9	0.6
1977	20.9	T	7.0	2.7	2.1					56.6	2.2	44.8	136.3	56.6	2.1
1978	44.0	3.1	29.3	0.6	0.6						15.1	14.1	106.8	44.0	0.6
1979	51.8	0.5	4.1	0.1	10.9	T				3.2	T	50.4	121.0	51.8	0.1
1980	16.8	54.1	16.8	0.6	0.2					T	1.8	41.6	131.9	54.1	0.2
1981	29.7	29.4	6.3	1.7	0.4					1.8	9.0	2.1	80.4	29.7	0.4
1982	31.1	17.7	16.7	2.8	4.8					7.8	32.8	15.1	128.8	32.8	2.8
1983	23.5	6.0	12.6	18.9	3.1	T					0.2	0.6	64.9	23.5	0.2
1984	14.8	1.8	17.3	T	T					T	41.2	8.2	83.3	41.2	1.8
1985	27.4	T	6.0	10.1	T						25.0	10.6	79.1	27.4	6.0
1986	11.9	16.7	20.1	17.2	5.6						18.6	20.4	110.5	20.4	5.6
1987	0.3	9.6	43.0	1.0	T					4.9		16.2	75.0	43.0	0.3
1988	37.8	9.2	13.3	0.8	T						0.4	8.0	69.5	37.8	0.4
1989	2.0	10.1	9.9	1.2	T						20.5	23.8	67.5	23.8	1.2
1990	14.9	18.3	6.5	T		*	*	*	*	*	*	*	39.7	18.3	6.5
1991	*	*	*	*	*	*				1.8	T	11.2	13.0	11.2	1.8
1992	22.3	8.5	22.0	1.6	7.2	T					13.7	30.5	105.8	30.5	1.6
1993	33.7	73.3	25.5	43.8	13.2					0.8	0.1	T	190.4	73.3	0.1
1994	5.2	T	11.3	9.9	1.0					7.7	56.0	18.1	109.2	56.0	1.0
1995	10.9	46.1	2.6	22.3	3.8	T				T	0.6	69.3	155.6	69.3	0.6
1996	59.6	29.9	70.2	21.5	0.4					T	3.1	2.7	187.4	70.2	0.4
1997	27.2		49.0	5.1	0.9					3.7	114.4	15.0	215.3	114.4	0.9
1998	41.4	8.4	58.9	2.8	0.2								111.7	58.9	0.2
1999													0.0	0.0	0.0
MEAN	25.8	18.6	16.8	14.9	5.5	0.5	0.0	0.0	0.0	7.8	19.1	20.3	110.6		
MAX	73.2	95.9	70.2	67.0	19.0	0.5	0.0	0.0	0.0	56.6	114.4	69.3	242.4		
Year	1972	1976	1996	1972	1967	1958				1977	1997	1995			
MIN	0.2	0.5	0.4	0.1	0.1	T				0.2	0.1	0.2			
Year	1973	1996	1963	1979	1974	MTY				1968	1993	1967			
TOTAL	1033	651	670	565	149	1	0	0	0	109	629	730	378		

* = Data not available

T = Amount is too small to measure

This table lists the intensities of rainfall observed at Kuwait International Airport (KIA) over the last forty-one years of common record.

Monthly Maximum Temperature (ºC)

Meteorological Department – Climatological Division, has provided the following information for the period 1958 to 1999.

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	MAX	MIN
1962	25.1	31.3	35.9	36.6	45.6	47.0	48.7	48.9	46.4	40.4	35.6	27.0	39.0	48.9	25.1
1963	26.4	31.0	30.3	40.5	43.6	47.5	48.5	49.0	45.2	41.0	35.5	25.1	38.6	49.0	25.1
1964	19.9	26.6	35.8	37.4	44.4	47.8	48.0	46.9	45.8	38.4	36.0	25.8	37.7	48.0	19.9
1965	22.6	26.2	35.0	38.7	46.4	47.4	48.6	47.7	46.7	41.6	32.8	27.7	38.5	48.6	22.6
1966	29.8	25.0	33.8	40.2	46.8	49.8	49.2	49.0	46.7	39.6	34.7	20.0	38.7	49.8	20.0
1967	27.5	22.8	30.4	33.3	43.2	44.8	49.2	45.9	46.1	39.2	34.8	23.7	36.7	49.2	22.8
1968	24.6	24.6	35.8	34.0	42.0	45.0	48.7	46.2	46.2	40.4	33.9	25.7	37.3	48.7	24.6
1969	25.6	35.8	41.2	41.2	44.7	47.6	46.5	47.3	45.5	43.2	34.5	25.4	39.9	47.6	25.4
1970	23.0	26.4	34.2	44.2	45.6	47.2	46.4	46.9	42.7	40.0	41.0	27.6	38.8	47.2	23.0
1971	24.0	28.1	34.3	37.0	43.6	44.4	46.3	46.6	46.0	38.6	43.2	28.5	38.4	46.6	24.0
1972	20.0	23.0	28.6	34.7	40.5	44.7	46.6	47.8	46.6	40.2	36.9	21.8	36.0	47.3	20.0
1973	26.5	30.2	28.6	36.7	46.0	48.0	48.3	48.6	47.5	40.9	39.6	25.0	38.8	48.6	25.0
1974	22.4	22.4	28.5	42.4	42.7	48.6	48.1	47.7	46.2	38.8	42.7	23.9	37.9	48.6	22.4
1975	25.3	23.3	31.6	37.0	46.0	46.4	49.6	47.7	46.4	38.2	44.6	25.3	38.5	49.6	23.3
1976	22.3	24.3	27.0	34.5	42.0	47.5	45.9	48.6	44.7	41.7	42.0	27.2	37.3	48.6	22.3
1977	19.6	28.7	32.7	35.5	44.4	47.2	47.0	48.8	45.8	40.9	43.1	28.7	38.5	48.8	19.6
1978	26.6	25.8	32.0	36.7	44.0	48.9	49.7	46.3	45.6	38.8	42.2	29.9	38.9	49.7	25.8
1979	25.4	29.7	34.0	44.0	45.2	48.6	49.4	46.5	47.5	41.4	41.7	24.8	39.9	49.4	24.8
1980	25.0	24.4	31.8	42.7	44.7	48.1	49.2	46.2	46.1	43.7	41.6	26.5	39.2	49.2	24.4
1981	25.0	25.8	33.4	39.7	43.7	49.2	48.3	50.7	46.3	40.7	43.5	28.4	39.6	50.7	25.0
1982	22.9	23.4	31.7	39.8	44.5	47.8	49.4	47.6	47.7	40.6	44.5	23.0	38.6	49.4	22.9
1983	23.4	24.7	27.8	36.0	44.8	46.1	50.6	47.9	45.2	41.2	42.2	29.5	38.3	50.6	23.4
1984	26.0	28.1	38.8	41.0	43.7	47.4	47.9	45.6	45.8	42.6	39.2	27.4	39.5	47.9	26.0
1985	28.0	28.4	34.1	38.5	46.1	46.5	47.4	49.0	45.6	42.2	44.1	29.6	40.0	49.0	28.0
1986	24.6	26.0	32.8	37.4	43.3	45.3	49.9	48.9	45.8	44.5	40.4	23.0	38.5	49.9	23.0
1987	26.6	31.5	29.6	40.0	44.4	49.1	50.6	50.6	45.8	42.3	41.1	27.0	39.9	50.6	26.6
1988	22.7	27.0	31.0	37.3	46.8	49.7	49.6	48.6	47.0	40.0	36.2	26.8	38.6	49.7	22.7
1989	22.6	23.3	30.3	38.0	46.1	48.9	48.8	49.3	46.5	40.8	31.0	28.1	37.8	49.3	22.6
1990	23.5	22.8	31.5	39.2	48.2	47.5	51.2	*	*	*	*	*	37.7	51.2	22.8
1991	*	*	*	*	*	*	48.0	47.9	45.3	39.3	37.5	30.4	41.4	48.0	30.4
1992	19.6	23.5	28.0	34.5	45.0	45.9	48.2	48.2	45.0	40.2	32.8	26.4	36.4	48.2	19.6
1993	24.2	29.3	32.0	39.9	43.0	47.8	49.9	49.7	47.7	41.5	32.5	26.2	38.6	49.9	24.2
1994	30.6	27.6	32.1	41.5	46.6	47.0	47.0	50.6	44.7	39.0	35.6	23.4	38.8	50.6	23.4
1995	24.9	24.2	32.0	37.8	44.4	48.0	48.1	51.0	45.8	40.0	36.0	20.9	37.8	51.0	20.9
1996	23.0	31.1	31.2	39.3	47.6	49.0	49.4	49.4	46.7	42.6	36.0	28.4	39.5	49.4	23.0
1997	25.0	33.0	27.7	37.5	45.2	48.9	48.8	48.2	47.7	44.0	31.1	24.7	38.5	48.9	24.7
1998	21.8	26.8	29.5	38.4	44.6	49.6	50.7	51.3	47.5	42.7	33.7	29.5	38.8	51.3	21.8
1999													0.0	0.0	0.0
MEAN	24.3	26.8	32.1	38.4	44.7	47.5	48.6	48.3	46.1	40.9	38.2	26.2			
MAX	30.6	35.8	41.2	44.2	48.2	49.8	51.2	51.3	47.7	44.5	44.6	30.4			
MIN	19.6	22.4	27.0	33.3	40.5	44.4	45.9	45.6	42.7	38.2	31.0	20.0			

* = Data not available

This table lists the maximum intensities temperatures observed at Kuwait International Airport (KIA) over the last 41 years of common record.

Monthly Minimum Temperature (ºC)

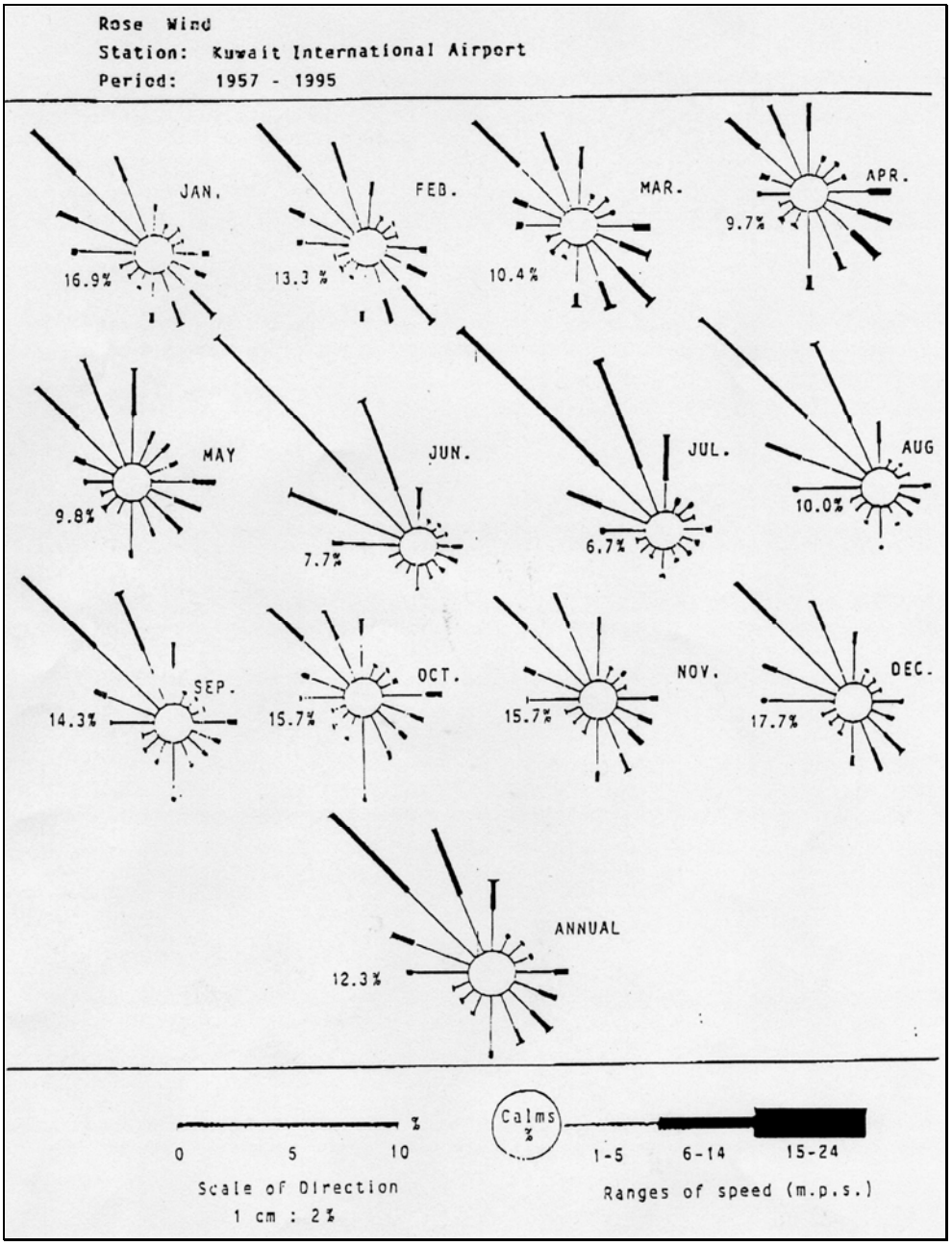
Meteorological Department – Climatological Division, has provided the information for the period 1962 to 1999.

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	MAX	MIN
1962	5.6	3.3	8.6	13.3	16.3	23.5	26.4	26.3	19.6	16.8	6.6	5.1	14.3	26.4	3.3
1963	6.0	7.2	6.2	16.6	15.0	22.3	25.9	26.8	21.0	18.5	5.7	-1.5	14.1	26.8	-1.5
1964	-4.0	2.6	8.8	13.6	15.2	26.0	26.7	23.7	20.0	11.6	2.6	1.3	12.3	26.7	-4.0
1965	0.8	4.7	8.3	10.3	16.8	25.3	26.8	25.1	22.2	16.9	7.8	0.2	13.8	26.8	0.2
1966	2.1	8.1	8.8	12.0	22.2	25.2	26.5	27.2	23.4	14.4	6.2	-2.0	14.5	27.2	-2.0
1967	0.2	-0.6	5.9	9.7	16.9	20.9	26.1	26.5	22.0	17.7	4.9	1.7	12.7	26.5	-0.6
1968	2.0	1.5	8.0	13.8	19.1	25.6	26.0	25.1	20.5	13.4	10.9	5.4	14.3	26.0	1.5
1969	4.0	3.4	12.4	11.6	19.6	23.7	25.6	25.2	21.2	17.0	7.1	4.8	14.6	25.6	3.4
1970	3.0	6.4	10.6	15.6	18.3	23.8	26.0	24.2	18.8	14.2	10.8	1.8	14.5	26.0	1.8
1971	4.5	0.9	7.4	13.2	19.7	20.4	25.3	23.5	18.8	14.0	8.0	0.5	13.0	25.3	0.5
1972	1.6	2.2	9.2	12.0	18.2	24.8	26.3	26.3	21.2	17.3	7.4	-0.7	13.8	26.3	-0.7
1973	-0.3	2.6	7.3	12.0	16.4	23.1	26.4	25.7	22.0	15.0	5.3	0.9	13.0	26.4	-0.3
1974	1.9	2.9	8.7	12.6	16.8	23.6	23.4	24.8	20.0	12.8	8.4	0.7	13.1	24.8	0.7
1975	2.7	1.7	6.6	11.4	19.2	24.4	27.4	26.4	23.3	14.5	5.9	0.9	13.7	27.4	0.9
1976	2.6	5.7	3.6	14.1	19.2	24.5	26.1	25.2	22.5	17.6	7.6	5.0	14.5	26.1	2.6
1977	1.0	6.5	7.6	14.7	21.3	25.5	27.2	24.8	23.1	11.5	9.8	5.6	14.9	27.2	1.0
1978	2.3	6.0	9.0	12.8	17.3	22.4	26.5	24.7	21.5	17.7	6.0	7.3	14.5	26.5	2.3
1979	5.2	6.7	7.9	15.6	16.6	27.1	26.7	26.5	23.0	18.0	10.6	3.0	15.6	27.1	3.0
1980	2.0	2.1	6.3	13.0	18.5	26.3	27.7	25.8	16.0	10.7	6.5	2.4	13.1	27.7	2.0
1981	2.5	3.0	7.5	6.9	14.7	22.4	24.0	23.6	18.9	13.0	4.5	6.9	12.3	24.0	2.5
1982	1.5	2.7	5.2	9.8	21.6	23.0	24.6	23.0	21.3	13.2	5.0	1.5	12.7	24.6	1.5
1983	-0.7	2.0	3.0	10.8	19.0	24.0	25.6	21.7	16.5	11.5	9.1	-1.0	11.8	25.6	-1.0
1984	0.3	1.4	4.5	12.4	15.2	21.4	25.6	21.9	20.6	9.4	11.2	2.7	12.2	25.6	0.3
1985	4.8	1.0	-0.1	13.5	19.5	22.3	22.4	22.8	18.4	9.6	11.6	2.5	12.4	22.8	-0.1
1986	-0.5	5.7	6.2	14.1	17.7	22.4	24.8	26.2	20.1	13.0	5.1	1.5	13.0	26.2	-0.5
1987	1.5	4.1	7.6	11.0	20.3	23.0	25.7	21.9	20.7	11.3	6.7	0.6	12.9	25.7	0.6
1988	-1.4	4.6	5.3	9.6	19.0	24.0	24.5	25.0	20.1	15.2	2.8	-1.4	12.3	25.0	-1.4
1989	-1.2	-1.6	7.4	8.0	20.0	23.2	25.8	24.9	18.1	11.6	8.6	4.4	12.4	25.3	-1.6
1990	0.7	3.7	5.0	11.6	18.0	23.5	25.3	*	*	*	*	*	12.5	25.8	0.7
1991	*	*	*	*	*	*	27.4	26.3	23.5	18.0	9.5	2.7	17.9	27.4	2.7
1992	0.7	3.1	5.7	14.4	19.8	26.5	27.8	28.0	22.6	17.0	5.3	4.0	14.6	28.0	0.7
1993	2.2	3.5	8.8	13.4	19.1	22.2	24.0	25.2	20.0	17.6	3.7	4.7	13.7	25.2	2.2
1994	3.3	1.4	7.5	14.4	20.0	22.5	25.7	23.8	22.2	17.6	10.5	0.7	14.1	25.7	0.7
1995	4.0	6.1	7.3	10.6	17.8	24.3	25.8	25.0	16.4	13.6	1.6	6.4	13.2	25.8	1.6
1996	4.5	5.6	9.8	13.0	20.7	23.4	24.6	25.8	19.6	11.7	6.8	5.6	14.3	25.8	4.5
1997	2.5	0.0	5.4	9.4	16.5	19.8	25.5	23.5	19.2	13.7	10.9	5.2	12.6	25.5	0.0
1998	1.6	2.1	6.7	13.1	18.1	24.5	25.7	25.0	22.0	13.0	9.5	4.5	13.8	25.7	1.6
1999													0.0	0.0	0.0
MEAN	1.9	3.4	7.1	12.3	18.3	23.6	25.8	24.9	20.6	14.4	7.2	2.6			
MAX	6.0	8.1	12.4	16.6	22.2	27.1	27.8	28.0	23.5	18.5	11.6	7.3			
MIN	-4.0	-1.6	-0.1	6.9	14.7	19.8	22.4	21.7	16.0	9.4	1.6	-2.0			

* = Data not available

This table lists the minimum intensities temperatures observed at Kuwait International Airport (KIA) over the last 41 years of common record.

Wind Direction and Speed



GENERAL SPECIFICATION

APPENDIX 3 - UNITS AND ABBREVIATIONS

List of Abbreviations:

ACI	American Concrete Institute
AISC	American Institute of Steel Construction
ANSI	American National Standards Institute
API	American Petroleum Institute
ASA	American Standards Association
ASCE	American Society of Civil Engineers
ASCII	American Code Standard Information Interchange
ASME	American Society of Mechanical Engineers
ASSHTO	American Association of State Highway and Transportation Official Standard Specification for Highway Bridges
ASTM	American Society for Testing Materials
AWS	American Welding Society
AWWA	American Water Works Association
BH	Bore Hole
BS	British Standard
BSCP	British Standard Code of Practice
BSI	British Standards Institution
BWL	Bottom Water Level
C/L	Centre line
CBR	California Bearing Ratio
CD-ROM	Compact Disc Read Only Memory
CIRIA	Construction Industry Research and Information Association
CP	Cathodic Protection
DAC	Data Acquisition and Control System-TIC
DI	Ductile Iron

DIN	German Industrial Standard
EMI	Electromagnetic Interference-TIC
FCV	Flow Control Valve-TIC
FM	Magnetic Flow Meter-TIC
FOC	Fibre Optic Cable-TIC
FW	Fresh Water
GII	Gulf Inspections International
HDC	Heavy Duty Coating
HMSO	Her Majesty's Stationery Office (England)
HT	High Tension
HV	High Voltage
I Mech E	The Institution of Mechanical Engineers
IEC	International Electrotechnical Commission
IEE	The Institution of Electrical Engineers
IP	Institute of Petroleum
ISO	International Organisation for Standardisation
JIS	Japanese Industrial Standards
KFB	Kuwait Fire Brigade
KIA	Kuwait International Airport
KOC or KNOC	Kuwait Oil Company
LDS	Leak Detection System-TIC
LED	Light Emitting Diode (lamp)
LSH	Level Switch high -TIC
LV	Low Voltage
MEW	Ministry of Electricity & Water
MPW	Ministry of Public Works

MOV	Motor Operated Valve-TIC
MWL	Maximum Water Level
NCC	National Control Centre (at Shuwaikh (A1))
NEMA	National Electrical Manufacturers Association
NR	Northern Region
NRCC	Northern Region Control Centre
OPC	Ordinary Portland Cement
OLE	Object Linking and Embedding (Microsoft Product) - TIC
OPC	OLE for Process Control-TIC
OWS	Operator Workstation-TIC
PC	Pre-cast Concrete
PC	Personal Computer-TIC
PCU	Process Control Unit (typically PLC, or DCS node)-TIC
PFA	Pulverised Fuel Ash (known as Microsilica in Kuwait)
PLC	Programmable Logic Controller-TIC
Private wire	Copper telecommunication cable owned by MEW
PSU	Power Supply Unit-TIC
PS	Pumping Station
PT	Pressure Transmitter-TIC
RFI	Radio Frequency Interference-TIC
SASO	Saudi Arabian Standards Organisation
SC	Standard Coating
SCADA	Supervisory Control and Data Acquisition System-TIC
SI	International System of Units
SIS	Swedish Standards Commission
SPS	Subiya Power Station

SPT	Standard Penetration Test
SR	Southern Region
SRCC	Southern Region Control Centre (at Mina Abdullah (E12) WDC)
SWDC	Subiya Water Distribution Complex (E20)
SWDS	Subiya Water Distribution Scheme
TCP/IP	Communication Protocol-TIC
TIC	Telemetry, Instrumentation and Control Systems.
TT	Temperature Transmitter-TIC
TWL	Top Water Level
UHF	Ultra-high Frequency-TIC
UK	United Kingdom
USA	United States of America
VDU	Visual Display Unit (typically colour monitor)-TIC
VHF	Very-high frequency-TIC
WDC	Water Distribution Centre
WIS	Water Industry Standard (UK)
XLPE	Type of electrical cable

NOTE: Refer to Section-6 for other relevant abbreviations.

Chemical Symbols:

Ca	Calcium
$CaCO_3$	Calcium carbonate
Cl	Chlorine
EPS	Polystyrene
$FRCl_2$	Free Residual Chlorine
GRP	Glass reinforced plastic
HCO_3	Bicarbonate
HDPE	High Density Polyethylene
K	Potassium
Mg	Magnesium
Na	Sodium
NaOH	Sodium Hydroxide (caustic soda)
NO_3	Nitrate
PVC	Polyvinylchloride
SO_4	Sulphate

Units

% w/v	Percentage weight of pure substance by total volume
% w/w	Percentage weight of pure substance by total weight
%	Percent
°C	Degrees Centigrade or Celsius
µS/cm	MicroSiemens per centimetre
A	Amperes
D	Day
Hr	Hour

Hz	Hertz (equivalent to ‘per second’)
kb/s	Thousand bits per second
KD	Kuwaiti Dinar
Kg	Kilogram
Km	Kilometre
KN	Kilonewtons
Kv	Kilovolts
Kw	Kilowatts
L	Litres
MR	metres
Masl	metres above sea level
Mbgl	metres below ground level
Mig	Million imperial gallons
Migd	Million imperial gallons per day
MVA	Mega Volt Amp
Rpm	Revolutions per minute
S	Second

APPENDIX 4 - REFERENCE STANDARDS

REFERENCE STANDARDS

ASTM 2487	Test method for classification of soils for engineering purposes.
ASTM A 975-97	Standard specification for double-twisted hexagonal mesh gabions and revet mattresses (metallic-coated steel wire or steel wire coated with polyvinyl chloride (PVC).
ASTM D 1556-90	Test method for density and unit weight of soil in place by the sandcone method.
ASTM D 1557-91	Test method for laboratory compaction characteristics of soils using modified effort (56.000 ft-lbf/ft³) (2,7000 KN-m/m³).
ASTM D 4253-91	Test method for maximum index density and unit weight of soils using a vibratory table.
ASTM D 4254-91	Test method for maximum index density and unit weight of soils and calculation of relative density.
ASTM D 698-91	Test method for laboratory compaction characteristics of soil using standard effort (12,4000 ft-lbf/ft³) (600 KN-m/m³).
AWWA C 105	Polyethylene encasement for Ductile iron pipe systems
AWWA C104/A21.4-95	Cement mortar lining for Ductile iron pipe and fittings for water
AWWA C111/A21.11	Rubber gasket joints for Ductile iron pressure pipes and fittings.
AWWA C502	Dry-barrel fire hydrants
AWWA C504	Butterfly valves.
AWWA C651	Standard for disinfecting water mains
AWWA M12	Simplified procedures for water examination
BS 1041	Temperature measurement
BS 1042	Measurement of fluid flow in closed conduits
BS 1052	Specification for mild steel wire for general engineering
BS 1199 and 1200	Specification for Building Sands from Natural Sources
BS 12	Specification for Portland cement
BS 1377	Methods of test for soils for civil engineering purposes.
BS 1400	Copper alloy ingots and copper alloy and high conductivity copper castings
BS 1452	Flake graphite cast iron
BS 1763	Specification for thin PVC sheeting
BS 1780	Bourdon tube pressure and vacuum gauges
BS 1881	Testing concrete
BS 2494	Elastomeric seals for joints in pipework and pipelines.
BS 2569: Part 1	Sprayed metal coatings.
BS 2789	Spheroidal graphite or nodular graphite cast iron

BS 2874	Copper and copper alloys rods and sections
BS 3251	Indicator plates for fire hydrants and emergency water supplies
BS 3416	Bitumen-based coatings for cold application suitable for use in contact with potable water
BS 3797	Specification for lightweight aggregates for Masonry units and Structural concrete
BS 3927	Rigid phenolic foam (PF) for thermal insulation in the form of slabs and profiled sections.
BS 4027	Sulphate-resisting Portland cement
BS 4147	Bitumen-based hot-applied coating materials for protecting iron and steel, including suitable primers where required.
BS 4190	ISO metric black hexagon bolts screws and nuts.
BS 4248	Specification for super sulphated cement.
BS 4320	Metal washers for general engineering purposes. Metric series
BS 443	Specification for testing zinc coatings on steel wire and for quality requirements.
BS 4449	Specification for hot-rolled steel bars for the reinforcement of concrete.
BS 4504	Circular flanges for pipes, valves and fittings.
BS 4504: Part3	Circular flanges for pipes, valves and fittings (PN-designated): steel, cast iron and copper alloy flanges.
BS 4999	General requirements for rotating electrical machines
BS 5075	Concrete admixtures
BS 5153	Specification for cast iron check valves for general purposes
BS 5156	Diaphragm valves
BS 5163	Predominantly key-operated cast iron gate valves for waterworks purposes.
BS 5163/86	Specification for key operated cast iron gate valves for waterworks purposes
BS 5292	Jointing materials and compounds for water, low pressure steam installations, 1^{st}, 2^{nd} and 3^{rd} family gases.
BS 6031	Code of practice for earthworks
BS 6076	Polymeric film for use as a protective sleeving for buried iron pipes and fittings.
BS 6105	Corrosion-resistant stainless steel fasteners.
BS 6187	Code of practice for demolition
BS 6755	Testing of valves

BS 6906	Methods of test for geotextiles
BS 6956: Part 5	Jointing materials and compounds: Jointing compounds for use with water, low pressure saturated steam, 1st family gases (excluding coal gas) and 2nd family gases.
BS 7079: Parts O & A1	Preparation of steel substrates before application of paints and related produces: Introduction and visual assessment of surface cleanliness.
BS 729	Specification for hot dip galvanised casting on iron and steel articles
BS 8010: Part 1	Pipelines on land: General
BS 8010: Section 2.1	Pipelines on land: design, construction and installation: Ductile iron
BS 812	Testing aggregates
BS 812: Part 103.1	Method for determination of particle-size distribution: sieve tests
BS 882	Specification for aggregates from Natural Sources for concrete
BS 970	Wrought steels for mechanical and allied engineering purpose: Part 1. General inspection and testing procedures and specific requirements for carbon, carbon manganese, alloy and valve steels.
BS EN 1514	Flanges and their joint – Dimensions of gaskets for PN-designated flanges.
BS EN 22063	Metallic and other coatings. Thermal spraying. Zinc, aluminium and their alloys.
BS EN 545	Ductile iron pipes and fittings
BS EN 593	Industrial valves – Metallic butterfly valves
CIRIA Report 97	Trenching practice
ISO 2531	Ductile iron pipes, fittings and accessories and their joints for water or gas applications
ISO 8179	Ductile iron pipe – External zinc coating
ISO 8770	High-density polyethylene (PE-HD) pipes and fittings for soil and waste discharge.
ISO 8772	High-density polyethylene (PE-HD) pipes and fittings for buried drainage and sewage systems.
SIS 05-5900	Pictorial surface preparation standards for painting steel surfaces.
WIS 4-52-01	Polymeric anti-corrosion (barrier) coatings

Or other relevant international recognized standards as subject to the Engineer approval.

MINISTRY OF ELECTRICITY AND WATER

WATER PROJECTS SECTOR

CONSTRUCTION AND MAINTENANCE OF 5 NOS. R.C. GROUND RESERVOIRS FOR FRESH WATER, 55 M.I.G CAPACITY EACH, AND ANNEXED WORKS AT MUTLA HIGH (STAGE-II)

SECTION 4A.2

SPECIFICATIONS OF INSPECTION AND TESTING

CONTENTS

4A.2 INSPECTION AND TESTING

4A.2.1 SCOPE

This Part covers particular requirements for inspection and testing of the Works.

4A.2.1.1 General

The Contractor shall carry out all tests and inspections as required by the appropriate Reference Standard or as considered necessary by the Engineer. The Contractor shall submit details, for approval, of all proposed factory tests within 2 months of the Date of Enterprise. The tests shall be no less exacting than those proposed by the Contractor in his Tender.

Inspections and test shall be carried out in the manufacturer's factory, or site or elsewhere.

If any tests are beyond the resources of the Contractor, supplier or manufacturer, then the Contractor shall arrange for the tests to be carried out elsewhere.

The Contractor shall ensure that all Sub-contractors, manufacturers and suppliers are given copies of the relevant specifications.

The costs of providing assistance and facilities to the Engineer or appointed inspectors for inspection and testing during the course of the Works shall be born by the Contractor.

Inspection, examination, and testing shall not release the Contractor from any obligation under the Contract.

4A.2.1.2 Specialist Inspection and Testing

The Employer may employ one or more specialist third party Inspection Agencies or firms to witness test and undertake inspections of materials and workmanship at any stage during the execution and maintenance of the Works.

The third party Inspection Agency or Agencies, whose fees will be to the Employer’s account, will be appointed shortly after the Date of Enterprise and will be advised to the Contractor in Writing.

4A.2.1.3 Access

The Engineer and/or Inspector shall be entitled at all reasonable times during the Contract to inspect, examine, and test materials on the Contractor’s or Manufacturer’s premises, in Contractor’s storage areas and compounds and any area of the Site at any time.

The Contractor shall provide all facilities and safety equipment necessary to allow the engineer to Inspect any part of the Works.

Manufacturers shall allow the Employers appointed Inspector or Inspection Agency free entry at all times and to all areas where work on the Contract is being performed and shall afford the Inspector, without charge, all reasonable facilities to satisfy him that the material/equipment is being manufactured in accordance with the Contract.

4A.2.1.4 Engineer's Inspection

No work shall be covered until it has been inspected by the Engineer.

4A.2.1.5 Rejection and Re-testing

If the Engineer and/ or Inspector decides that any work material is defective or is not in accordance with the Contract, they shall give in writing notice of rejection, stating the grounds upon which the decision is based.

If any item or material fails or is rejected it shall be replaced or rectified and the item or its replacement shall be offered for re-testing and inspection. Any resulting additional expenses incurred by the Engineer, Employer or Inspector shall be borne by the Contractor.

The Contractor shall meet any extra costs which result from the failure of the Contractor to comply with the requirements for testing and inspection or which result from insufficient preparation taken by the Contractor before presenting work or materials for inspection or test.

Any item may be subject to random re-testing as directed by the Engineer.

4A.2.1.6 Test Certificates

The Contractor shall submit test certificates giving a detailed record of all tests carried out within two weeks of completion of the tests. Test certificates shall certify that the item has been satisfactorily tested. They shall describe and give full particulars of the tests and shall attach copies of any test curves, test data and results.

Copies of test certificates for major items shall be included in the operation and maintenance manuals.

4A.2.2 FACTORY WITNESS TEST AND INSPECTIONS

The Contractor shall offer manufactured items for inspection examination and witness testing at all stages during manufacture.

Within 2 weeks of the Date of Enterprise the Contractor shall submit his proposed programme for factory tests and Inspections.

Detailed programmes shall be submitted monthly.

Wherever possible inspections and tests will be conducted so as not to interfere unnecessarily with the operation of the factory.

4A.2.2.1 Factory Tests

Factory testing shall include:

4A.2.2.1.1 Pressure Tests

All pressure pipes, fittings and valves, shall be hydraulically tested to the pressure specified in the Contract or in the appropriate Reference Standard.

4A.2.2.1.2 Valves

Factory tests on valves and associated equipment shall be carried out as specified below:

Gate valves (sluice valves)

Each gate valve shall be tested at the manufacturer's works in accordance with the requirements of BS 5163. Valve seat tests shall be made under open-end conditions, the test pressure being applied to each face of the valve in turn.

Butterfly valves

Each butterfly valve shall be tested at the manufacturer’s works in accordance with BS EN 593,

Air valves

Each air valve shall be tested hydrostatically in accordance with BS 6755: Part 1, except as specified below. Durations for tests shall be as given in Table 4 of BS 6755.

Seat tests shall be carried out at the lowest seating pressure specified and at four equal pressure increments up to 1.1 times the maximum permissible working pressure. The maximum permissible seat test leakage rate at each test pressure shall be rate A as defined in Table 1 of BS 6755. The back seat test shall not apply.

Two valves of each type and size incorporating large orifices shall be tested for exhaust of air at a differential pressure up to 1 bar in steps of 0.1 bar and for inflow of air at a differential pressure up to 0.5 bar in steps of 0.1 bar. During the tests the air flow rates shall be measured by orifice plates in accordance with BS 1042. Pressures (positive or vacuum) shall be measured by Bourdon tube gauges in accordance with BS 1780, or by means of mercury-in-glass manometers. The temperature of the flowing air shall be measured in accordance with BS 1041: Part 1 and Part 2. The barometric pressure shall also be measured.

If the manufacturer provides results of independently-witnessed air-flow tests similar to those specified and these are accepted by the Engineer, the specified air-flow tests shall be deemed to be completed.

Check valves

Valves manufactured in accordance with BS 5153 shall be tested to that standard.

Valves manufactured to other standards shall be hydrostatically tested where applicable, in accordance with the manufacturing standard, providing that the testing requirements are at least as rigorous as those specified below for testing in accordance with BS 6755: Part 1. Otherwise, testing shall be in accordance with BS 6755: Part 1.

Pressure test durations for tests under BS 6755: Part 1 shall be as given in table 4 of that Standard. The maximum permissible seat test leakage rate shall be as defined in table 1 of BS 6755: Part 1 and shall be Rate B for metal-seated valves and Rate A for resiliently-seated valves. The back seat test shall not apply.

Additionally, each valve shall be shown to control flows satisfactorily in accordance with the specified criteria throughout the full specified range of pressures and flows, to the approval of the Engineer.

4A.2.2.2 Scope of Factory Inspections

The following inspections will be performed or witnessed by the appointed Inspector/Agency and/or by the Engineer.

Visual inspection of all valve bodies and bonnets internally and externally after machining and prior to coating or painting.

Witness ultrasonic thickness inspection of 10 valves or 20% of the total quantity whichever is the greater for wall thickness of both body and bonnet.

Witness dye-penetrate examination of all gates/discs and seat rings where hard facing is over laid.

Dimensional inspection of 10 valves or 20% of quantity whichever is greater. Dimensions will include face to face, PCD of flange bolt-holes, flange thickness, stem diameter and bonnet flange thickness.

Quality and thickness of internal and external epoxy coating.

Inspection of manufacturer’s material and test certificates for valve materials including body, bonnet, disc, stem, nut, body seat, disc seat, cap, hand wheel, bolts, nuts, washers and ensure that certificates are related to material by serial numbers.

Witness shell and seat pressure tests according to the applicable standard for 90% of valves. (No visible leakage shall be permitted during tests).

Witness all functional tests.

Check markings according to the applicable Reference Standard and the Specification.

Witness packing to ensure the following:

- All valves shall have tropical packaging;
- Each flanged end is effectively and securely sealed against the ingress of dust and water.

a. Valves are packed with the gate/disc in completely closed position.

b. For valves with actuators, the valve and the actuator are in fully assembled condition. Actuator openings/connectors are effectively and securely sealed against the ingress of dust and water.

c. All loose items are tagged with their part numbers and packing list reference numbers.

d. Each item is clearly identified in the packing list and carries the correct markings.

e. A copy of the packing list is included in each packing case or container.

f. The case is stamped or stencilled at a visible place by the appointed Inspection Agency to show that the packing has been inspected, and the contents tally with the packing list. (This is not required if materials are packed in shipping containers).

4A.2.2.3 Pipes and Fittings

The test and inspection of ductile iron pipes and fittings witnessed by the Inspection Agency shall include but not be limited to the following:

i) Audit of manufacturer’s quality programme.

ii) Check of drawings and specifications.

iii) Review of mill sheets.

iv) Document checks for materials received from sub-vendors.

v) Microscopic observation for graphite and annealing effect.

vi) Chemical examinations.

vii) Mechanical test (the dimensions of test bars and test method shall conform to standard specifications).

viii) Witnessing of factory hydrostatic test:

- The hydrostatic test shall be carried out on pipes and fittings before application of the coating.
- Leakage from the pipes and fittings shall be checked visually.

ix) Verification of dimensions (thickness and length):

- Checking of dimensions shall be carried out on the pipes and fittings using various limit gauges, measuring scale or callipers.

x) Mass verification:

- Checking of mass shall be carried out on pipes and fittings as standard.
- Weighing may be carried out after coating.

xi) Coating Inspection:

- Visual inspection shall be carried out on the coating surface of each pipe and fitting.
- The coating thickness of pipes and fittings shall be measured using a magnetic thickness gauge.
- Internal surface coating of socket and external surface coating of spigot of pipes and fittings.
- Review of all coating materials sheets.

xii) Cement Mortar Lining Inspection:

- Visual inspection shall be carried out on the lining surface of pipes and fittings.
- The lining thickness at both ends of the pipes and fittings shall be checked using a measuring scale.

xiii) Seal Coat Inspection

xiv) Shapes, Marking and Appearance Inspection

- Visual inspection shall be carried out on all pipes and fittings.

4A.2.2.4 Test and Inspection of Accessories

The test and inspection programme/work of accessories shall include but not be limited to the following:

i) Rubber Gasket:

- Visual inspection for the appearance and the shape shall be carried out on all pieces.
- Dimensional checking and physical tests shall be carried out on a sample taken from a batch which shall be made up of pieces as given below:
-

Nominal Dia. (mm.)	Pieces of Rubber Gasket in each Batch (pcs.)
Up to 300	900
400 and 600	500
800, 900 and 1200	200

ii) Gland for Mechanical Joint:

- Visual inspection for the appearance and the shape shall be carried out on all pieces.
- Dimensional checking shall be carried out using various limit gauges and/or measuring scales.
- Mechanical test shall be carried out in accordance with the test method for fittings.

4A.2.2.5 Reduced Tests for Identical Items

Where items are of an identical type and duty rating it may be required, subject to the Engineer's written instructions, that a reduced number of items are subjected to witnessed testing.

Wherever part quantity inspection and testing is specified or approved failure of one item will necessitate 90% inspection of the remaining items.

4A.2.2.6 Notice

The Contractor shall give the Engineer/Inspector a minimum of twenty (20) days written notice of the date and the place at which the materials will be ready for inspection or

testing. Unless the Engineer attends at the place named within twenty one (21) days after the date stated in the notice, the Contractor may proceed with the tests, which shall be deemed to have been made in the Engineer's presence, and he shall submit to the Engineer four (4) certified copies of the test readings.

The Engineer/Inspector shall give the Contractor 24 hours notice in writing of his intention to attend the tests.

The Contractor shall give the Engineer and/or Inspector a minimum of fourteen (14) days notice in writing of the date on and the place at which the materials are ready to be packed and shipped. Unless the Engineer and/or Inspector attends on the stated date the Contractor may pack and ship the Materials. The Contractor shall submit to the Engineer four (4) certified copies of the shipping documents.

The Engineer/Inspector shall give the Contractor 24 hours notice in writing of his intention to inspect any materials before packing.

4A.2.2.7 Liaison

The Contractor shall liaise directly with the Inspection Agency to arrange mutually convenient inspection times. Should the Contractor be unable to contact the Inspection Agency the supplier should inform the Engineer with precise details of his attempts to make contact including copies of telefaxes.

4A.2.2.8 Assistance

Where inspections or tests are undertaken on the premises of the Manufacturer the Contractor shall, except where otherwise specified, provide all assistance, labour, instruments as may be required and as may be reasonably demanded to carry out the inspections or tests efficiently.

4A.2.2.9 Shipment

No manufactured item shall be despatched from the manufacturer's factory without a written Release Note of Acceptance from the appointed Inspection Agency or the written permission of the Engineer. Any items despatched without such permission shall be returned to the place of manufacture and further presented for inspection and witnessed testing in accordance with the Specification at the expense of the Contractor.

Shipping documents shall comply with section-3 of the General terms & conditions.

4A.2.2.10 Submittals

The Contractor shall provide 4 copies of inspection reports and packing list duly certified by the Employer's Inspector.

4A.2.3 SITE TESTING

4A.2.3.1 Site Testing Proposals

Within three (3) weeks from the Date of Enterprise the Contractor shall submit his proposals for site testing and quality control.

The proposals shall include details of the Contractor's proposed laboratory facilities including details of the tests he intends to conduct on site and those he proposes to sub-contract to an independent off-site laboratory.

4A.2.3.2 Programme and Notification of Tests

The Contractor shall programme site testing and shall ensure that all parties concerned are informed in advance and are present during any tests.

4A.2.3.3 Site Laboratory

The Contractor shall establish a Site Laboratory, with all facilities and equipment necessary to undertake routine monitoring of site quality control such as determination of:

- Moisture content
- Grading
- Concrete slump
- In-situ density tests.

With the approval of the Engineer performance monitoring tests such as crushing of concrete cubes and compaction testing of soil samples may be undertaken either in an on site laboratory or at an independent off site laboratory.

The Engineer shall be permitted free unhindered access to all laboratories approved for use in any testing in connection with the Works.

--- END OF SECTION ---

MINISTRY OF ELECTRICITY AND WATER

WATER PROJECTS SECTOR

CONSTRUCTION AND MAINTENANCE OF 5 NOS. R.C. GROUND RESERVOIRS FOR FRESH WATER, 55 M.I.G CAPACITY EACH, AND ANNEXED WORKS AT MUTLA HIGH (STAGE-II)

SECTION 4A.3

SPECIFICATIONS FOR

PIPELINE TESTING, CLEANING, DISINFECTION & COMMISSIONING

CONTENTS

4A.3 PIPELINE TESTING, CLEANING, DISINFECTION AND COMMISSIONING

4A.3.1 METHOD & PROGRAMME OF PIPELINE TESTING AND CLEANING

The Contractor shall submit for the approval of the Engineer details of his proposed methods and programme for pipeline testing, swabbing, disinfection and cleaning (including details of test and cleaning equipment).

All water pipelines shall cleaned, pressure tested and disinfectected.

Cable ducts shall be cleaned and left stoppered with draw cords.

All chambers and draw pits shall be cleaned of all debris silt and sand, any mortar droppings on pipework or metalwork shall be removed and any damaged coatings made good. Valves shall be tested for operation, valve spindles shall be adjusted for correct alignment and chamber covers shall be cleaned and properly seated.

Records of all cleaning, testing and disinfection operations shall be submitted to the Engineer weekly

4A.3.1.1 Water for Testing, Cleaning, Swabbing and Disinfection

The Contractor shall provide all water required for testing and cleaning and disinfection of pipelines. The Employer will wherever possible and if required by the Contractor make available metered supplies of water from vicinity of the site.

The Contractor shall provide all necessary temporary connections, pipework and any tankers necessary to convey water from the point of supply.

The cost of all arrangements & water to be used will be on contractor’s account.

The Employer cannot guarantee the quantities, the flow rates or the pressures of supplies.

Waste water shall be discharged only on to sites or into conduits that are suitable. Discharges shall not cause damage, create a nuisance or health hazard, or interfere with the work of others. The Contractor shall obtain the consent of the Engineer and relevant authority before discharging any water to a watercourse.

Where directed by the Engineer water may be re-used in testing or cleaning other parts of the Works or in works being executed for the Employer by other Contractors.

4A.3.2 VALVES

All valves shall be tested on completion of installation. Each installation shall be checked for water tightness. Valves shall be demonstrated to function satisfactorily under design maximum differential head conditions.

The Contractor shall carry out a final test and inspection of valves and associated equipment immediately before pressure testing the pipeline.

Where directed by the Engineer valves shall be internally inspected after testing to verify that the seals remain in a satisfactory condition.

4A.3.3 TESTING PIPELINES

4A.3.3.1 General

All parts of pipeline systems shall be subjected to hydraulic pressure testing.

Testing may be undertaken in sections as the work proceeds but the whole system shall be subjected to a final test.

For the purposes of this final test, the pipeline system shall be divided into suitable sections according to sectional isolation valves and or as agreed with the Engineer. Testing shall not be carried out against closed valves, hence blank flange shall be used upstream / downstream of the valve.

All testing shall be witnessed and approved by the Engineer.

4A.3.3.2 Test Equipment

The Contractor shall supply water, pressure gauges, pressure recorders, meters, hoses, pumps, stop ends and all other equipment necessary for carrying out tests.

Pressure gauges shall be minimum diameter 90mm and shall have a full-scale reading of not more than twice the maximum pressure being tested. The Contractor shall provide the Engineer with a recent independent test certificate for each pressure gauge and pressure recorder.

4A.3.3.3 Anchors

The Contractor shall provide and install all necessary stop ends and temporary thrust restraints to carry out the tests. Pressure tests shall not be made against closed valves, hence blind flange shall be temporary inserted.

The Contractor shall satisfy himself and the Engineer that all temporary and permanent structures and thrust blocks are capable of withstanding the forces exerted from hydraulic tests with a sufficient factor of safety. Calculations shall be submitted to the Engineer for approval.

Thrusts from hydraulic test pressures shall not be exerted on any permanent structure that is located in saturated ground where the standing water level is above the lowest level of the foundation without the approval of the Engineer.

The Contractor shall provide any additional support or kentledge to structures as necessary to withstand the test pressures.

No loadings from testing shall be imposed on any structure without the approval of the Engineer. Notwithstanding any approval given by the Engineer, the Contractor shall be fully responsible for any consequences arising from the testing.

Where more than one pipe is laid in a common trench only one pipeline shall be pressurised at any one time.

4A.3.3.4 Procedure for Site Pressure Testing Pipelines for Water Supply

Before filling pipelines for pressure testing, the Contractor shall re-check pipes and valves for cleanliness and shall re-check the operation of all valves.

The ‘open’ ends of the pipeline (or sections thereof) shall be stopped off by blank flanges or cap ends secured by temporary struts, wedges and thrust blocks.

All permanent thrust blocks and valve chambers shall have been completed and backfilled and the concrete shall have attained its specified 28-day strength

All pipe straps and other devices intended to prevent the movement of pipes shall be securely fastened.

Joints including spigot and socket joints shall be left exposed for inspection during pressure testing and trenches between pipe joints shall be backfilled to the extent necessary to prevent movement of the pipeline.

The test section shall be filled with water and all air removed.

The pipeline shall stand full of water for at least 24 hours at the working pressure and all joints and restraints shall be inspected for leakage and movements.

The pressure shall then be raised by pumping in water until the specified test pressure is reached. The pressure shall be maintained at the test pressure by further pumping for a

period of not less than 1 hour during which time the pipeline shall be again inspected for leakage or movement.

Pumping shall then cease and the time (T) for the pressure head to fall by 10m shall be recorded. If the pressure head has not fallen by 10m within three hours, then the fall in head at 3 hours shall be recorded. Pumping from calibrated container(s)shall then be resumed to restore the pipeline pressure to the test pressure. The quantity of water (Q) pumped into the pipeline shall be recorded.

The rate of loss shall be calculated as being the quantity (Q) pumped into the pipeline divided by the time (T).

4A.3.3.5 Test standard for Pressure Pipelines for Water Supply

Testing of installed pipelines shall be carried out according to Clause 29 of BS 8010: Section 2.1 : 1987.

4A.3.3.6 Action Following Test Failures

If the pipeline (or a section thereof) fails to pass the pressure test the Contractor shall locate the faults and shall uncover, repair, retest and reinstate the pipeline as may be necessary until all parts of the pipeline shall have passed the pressure test.

4A.3.3.7 Working Pressure and Site Test Pressure

The working pressure and test pressures of the different sections of pipeline, shall be as shown on the Drawings.

4A.3.4 CLEANING OF PIPELINES

4A.3.4.1 Water Pipelines

Before commencing pressure testing, the Contractor shall clean out the part of the pipeline to be tested to the approval of the Engineer.

Materials and equipment necessary for cleaning shall be provided by the Contractor.

After the whole pipeline has been successfully pressure tested (whether as a whole or in sections) and the Contractor has reconnected any parts temporarily removed from the pipeline, the Contractor shall finally clean out the whole pipeline and flush it through with clean water.

The Contractor shall be liable to the Employer for any damage caused to the pipeline or to pumps and other equipment of the Employer as a result of foreign matter of any kind not having been cleared out of the pipeline.

4A.3.4.2 Cleaning of Cable Ducts

Pipes laid as cable ducts shall be kept thoroughly clean and all pipe ends shall be kept stoppered off with expanding rubber plugs.

Ducts shall be proved by pulling through a train consisting of an approved badger and a circular rubber squeegee followed by a wooden ball.

The wooden ball shall not be smaller than 25mm less in diameter than the pipe.

After cleaning ducts shall be provided with draw cords.

4A.3.5 SWABBING OF PIPELINES FOR WATER SUPPLY

Water pipelines shall be swabbed after pressure testing and before disinfection by passing a foam swab through the pipeline.

The swab shall be non-abrasive and shall fit compressed into the pipeline. Swab stiffness shall be selected to suit the pipe and lining material.

The swab shall be driven at a velocity of between 0.3m/s and 1.0m/s by the admission of treated water.

Sufficient passes of the swab shall be made to produce clear water.

Swabs and debris from the pipe shall be disposed of to suitable locations by the Contractor. Flushing water shall be disposed of as specified in Clause4.A.3.1.1.

All materials and equipment, including temporary swab insertion and retrieval points and temporary connections to the source of water shall be provided by the Contractor.

4A.3.6 DISINFECTION OF PIPELINES

Disinfection of pipelines shall be carried out in accordance with AWWA C65.

The Contractor shall provide all materials and equipment necessary for disinfection.

Liquid chlorine, calcium hypochlorite or sodium hypochlorite may be used for disinfecting.

Liquid chlorine shall be used only in conjunction with proper equipment and under the supervision of qualified personnel who are familiar with the physiological, chemical and physical properties of this material and who are properly trained and equipped to handle any emergency that may arise.

Pipelines shall be disinfected by the continuous feed method. Water entering the pipeline shall be maintained at a minimum of 20mg/l available chlorine or such level as may be necessary to ensure that at the end of 24 hours the treated disinfecting water shall contain not less than 2mg/l of chlorine at all points in the pipeline being disinfected. The chlorine concentration shall be measured at regular intervals in accordance with AWWA M12 to ensure that the required concentration is maintained.

After the required retention period, the heavily-chlorinated water shall be flushed from the main using potable water until the chlorine concentration in the water leaving the main is no higher than that generally prevailing in the systems and not exceeding 0.1mg/l. Chlorine-residual determinations shall be made to ascertain that the heavily chlorinated water has been removed from the main.

Dechlorination shall be carried out if necessary and as instructed by the Engineer in order to achieve an acceptable low level of residual chlorine in the discharge.

After final flushing samples shall be collected from a sampling cock with a copper tube gooseneck located at the end of the pipeline which is remote from the source of supply and tested for bacteriological quality. The sampling cock shall remain in place upon completion of the test.

The samples shall show the absence of coliform organisms.

Samples shall be collected directly from the sampling cock in sterile bottles treated with sodium thiosulphate. No hose or fire hydrant shall be used in the collection of the samples.

If the initial disinfection fails to produce satisfactory samples, disinfection shall be repeated until satisfactory samples have been obtained.

4A.3.7 COMMISSIONING

Commissioning will be undertaken by the Contractor; the contractor shall submit commissioning procedures for the Engineer approval.

4A.3.8 PUTTING INTO SERVICE

Putting into service will be undertaken by the Employer and Employer's Representative. The Contractor shall provide attendance during the putting into service operation and shall provide any assistance that may be required by the Employer's representative.

--- END OF SECTION ---

MINISTRY OF ELECTRICITY AND WATER

WATER PROJECTS SECTOR

CONSTRUCTION AND MAINTENANCE OF 5 NOS. R.C. GROUND RESERVOIRS FOR FRESH WATER, 55 M.I.G CAPACITY EACH, AND ANNEXED WORKS AT MUTLA HIGH (STAGE-II)

SECTION 4A.4

SPECIFICATIONS OF MATERIALS HANDLING, STORAGE AND MARKING

CONTENTS

4A.4 MATERIALS HANDLING, STORAGE AND MARKING

4A.4.1 SCOPE

This section of the Specification covers procurement, marking handling and storage of materials.

Materials means all materials and manufactured items intended for permanent installation in the Works.

Manufactured items means any factory fabricated item including pipework, miscellaneous metalwork, access covers, ladders and the like.

Pipework means pipes, fittings, valves and all ancillaries.

4A.4.2 PLACING OF ORDERS FOR MATERIALS

The Contractor shall not place any orders for the materials without the prior written consent of the Engineer.

The materials offered shall be proven to operate satisfactorily in a similar application to that required for this Contract.

4A.4.3 SHIPPING FORMALITIES

4A.4.3.1 Advice of Despatch

The Contractor shall obtain the Employer's approval before shipment. All shipping documents shall be drawn in favour of MEW and shall be submitted to the Employer for endorsement in ample time before the arrival of the materials and equipment at the port of destination.

4A.4.3.2 Customs Clearance

The Contractor shall be responsible for all customs clearance formalities.

4A.4.3.3 Shipping Documents

The Contractor must include with the shipping documents the appropriate inspection and test certificates and reports made during manufacturing and the following:

- Certificate of Origin Countersigned by the Chamber of Commerce in the country of Origin, and attested by Kuwait Embassy or where Kuwait has no diplomatic representation any other Arab Embassy;

- Certificate indicating the vessel departure date and estimated date of arrival (EDA) at Kuwait;
- Invoice of the shipped consignments;
- Insurance policy or confirmation of Insurance declaration;
- Packing List;
- Any other document called for by the Contract.

The documents referred to above should be prepared and submitted in one original group and additional Photostat groups in compliance with the Contract.

4A.4.4 PROTECTION AND PACKING

The Contractor shall ensure that materials arrive at the Site intact and undamaged. Before despatch from the place of manufacture materials shall be adequately packed and protected, by painting or by other approved means, to give protection against corrosion and accidental damage for the whole period of transit, storage and erection.

All materials as necessary shall be packed in first quality containers or packing; no second-hand timber shall be used. The materials shall be packed to withstand several stages of rough handling in transit and possible delays in delivery. Packaging shall be weather proof, suitable for transport by sea or air freight as appropriate, inland transport and storage and movement on Site.

Lids and internal cross battens of all timber packing cases shall be fixed by screws and not nails.

Flanges of pipes, sluice valves and fittings shall have their open ends protected by adhesive tape or jointing and then be protected by wooden discs secured by means of service bolts which shall not be used on Site.

All other pipe ends shall be protected against impact damage and entry of foreign matter.

Sleeves and flanges of flexible couplings shall be bundled by wire.

Valves shall be packed in the ‘closed position’ except that crated resilient-seat gate valves shall be in the ‘open position’. Valves shall be provided with all necessary packing to prevent movement or damage of the gate and other parts during transit.

Small items, such as bolts, nuts, gaskets and other joint components shall be crated for delivery. Each crate shall contain a detailed packing list in a waterproof envelope. The outside of the crate shall bear a general description of the contents and an identification mark relating it to the detailed packing list.

Accessories such as bolts and nuts shall be packed in cartons, wrapped in nylon sheets and then placed in wooden boxes. For bolts and nuts the box size shall be 100 cm. x 50 cm. Cases containing rubber rings, bolts and other small items shall not normally weigh more than 500kg gross.

The Contractor shall submit details of any packaging as may be requested by the Engineer prior to despatch. The Engineer at his discretion may inspect any packing before the items are despatched.

4A.4.5 SHIPMENT

Pipes & fittings shall be packed and arranged in the ship's hold in a way to protect them from any damages.

The Contractor shall supply and maintain sufficient cranage, trucks and the like for the unloading of materials from the ships and transportation to the Site.

The Contractor shall provide close supervision at the port of Kuwait during unloading operations.

The Contractor's representative together with the Employer's representative shall examine all materials on arrival at Site and any material which is damaged or does not conform to the Contract shall be rejected.

The Contractor shall supply with each shipment proper handling equipment to permit handling without damage.

4A.4.6 MARKING

All packaging shall be clearly and indelibly marked for identification against the packing list, in Arabic and English. Cases shall bear the Contractor's name and the name of the Employer and the Contract name and number.

All marks on the outside of casings are to be either of a waterproof material or protected by shellac or varnish to prevent obliteration in transit.

Structural steel work, pipes, sluice valves, uncased fittings and metalwork shall bear despatch marks in suitable paint or other approved medium. When in the opinion of the Engineer the despatch marks cannot be applied satisfactorily to any item they shall be stamped on a metal label attached to the item or part by means of a piece of wire passing through holes at either end of the label and secured so that it lies flat with the item.

All cases and packages shall be clearly marked on the outside with a waterproof material to show the weight, where the weight is bearing, and where the slings should be attached.

Each case or package shall contain a packing list in a waterproof envelope. Copies of the packing list in duplicate shall be submitted to the Engineer prior to despatch. All items of material are to be clearly marked for ready identification against the packing list.

4A.4.7 HANDLING OF UNCRATED MATERIALS

The Contractor shall not use methods, plant or equipment which may cause damage to materials and he shall ensure that during all handling operations no damage is caused to materials or exterior and interior coatings.

Handling equipment shall include lifting beams, reinforced canvas slings, protective padding, struts, cradles, rope or nylon slings and timber packings to ensure that the surface finishes of items are not damaged.

On no account shall pipework be lifted with hooks in the pipe end or with wire-rope or chain slings.

Temporary packing, coverings or crates provided for the protection of materials in transit shall not be removed (except for purposes of inspection after which they shall be replaced) until immediately before installation.

4A.4.8 INSPECTION AND DEFECTS

The Contractor shall inspect all materials on receipt at Site and shall take immediate action as necessary to rectify any deficiency or defect.

Pipes, fittings and valves shall be inspected by the Contractor immediately before and after installation and any damage shall be repaired or the item replaced, as directed by the Engineer.

Any special material required for the repair of pipe lining, coating or protection shall be obtained from the pipe supplier and shall be used in accordance with his recommendations.

The Engineer may inspect and test the pipeline materials by any means he considers appropriate at any time and any damage discovered by such inspection shall be repaired by the Contractor.

The Contractor shall remove from the Site and shall provide a replacement for any pipe or fitting which in the opinion of the Engineer is so badly damaged as to be unfit for repair.

4A.4.9 SAFEKEEPING AND STORAGE

All materials shall be handled and stacked with sufficient care to prevent damage to the material and any protective coatings.

The Contractor shall be responsible for the security and maintenance of all materials up to their installation and Completion of the Works.

The contractor's storage arrangements shall be secure and shall be designed giving due consideration to the adverse environment.

The Contractors storage arrangements shall be subject to the approval of the Engineer.

4A.4.9.1 Storage of Pipework

Pipes and fittings at all times prior to installation shall be stored on a firm dry flat area laid on wedged timber bearers so as to be at least 150mm clear of the ground. The bearing capacity of the storage area shall be adequate to prevent settlement of the timber bearers and the area shall be provided with falls or other drainage provisions to prevent ponding of storm water. Pipes supplied on pallets or crated shall remain on the pallets or crated until required. End covers and protection shall not be removed except for inspection until immediately prior to incorporation into the pipeline. Subject to the manufacturer's recommendations non crated pipes may be stacked up to two pipes high if suitable protective packing is placed between the layers. Pipes of different materials, sizes, wall thicknesses and lining thicknesses shall be stacked separately. All pipes and fittings shall be suitably cushioned at all points of support so as to prevent damage to the pipe wrapping or coating.

The period between taking delivery of a pipe and the completion of its installation shall be kept to a minimum. Pipes may be strung out along the pipeline route prior to installation providing that any necessary temporary fencing has first been erected. Jointing and wrapping parts and materials shall be stored under cover. Pipes and fittings liable to be affected by exposure to ultra-violet radiation shall be kept under cover except when being handled during delivery or installation

4A.4.10 UNLOADING ERECTION AND HANDLING OF MATERIALS

When loading, unloading and installation of materials is undertaken adjacent to structures using a mobile or static crane, the Contractor shall ensure that the maximum superimposed load exerted by such lifting plant shall not exceed 100 kN/m^2 on the standing surface.

The Contractor shall during progress of the Work remove from the Site all surplus packaging and materials.

4A.4.11 PERMANENT LABELS AND MARKING

The Contractor shall supply and fit engraved labels on all valves and equipment. The labels shall show the equipments reference number.

The size of labels should not be less than 100mm x 50mm and lettering shall be in English.

Labels shall be stainless steel engraved filled with black paint and shall have chamfered edges. The Contractor shall mount the labels in positions designated by the Engineer using either chrome plated nuts and bolts or screws.

4A.4.11.1 Pipework

In addition to the requirements of ISO2531 each pipe, fitting and valve shall be indelibly marked over any factory-applied coating with the letters M.E.W, the Contract number and a unique reference number to enable items to be correlated to works fabrication records, works test certificates, delivery notes and the like. Wherever possible, the marks shall be painted both on the inside and outside of pipes and fittings close to one end which, in the case of pipes and fittings with socket and spigot joints, shall be the socket end.

Marking shall be at least 50mm high. (25mm on valves and small items).

Markings shall be in the form:

AAA/BBB/CCC/DDD/EEE.

Where AAA is the name of the manufacturer

BBB is the Contract number

CCC is the working pressure rating of the item

DDD is the pipe diameter in millimetres

EEE is a unique reference number

Where there is insufficient smooth surface area to accommodate the above information the marking shall be put on rustproofed metal tags secured to the item with galvanised wire.

Pipes and fittings shall have marks to ensure the correct register of spigots in sockets (for example two white painted lines).

4A.4.11.2 Valves

Each valve body shall be marked by cast-on or stamped figures as follows:

- Size of Valve
- Year of Manufacturing
- Working Pressure
- Type of Casting

4A.4.12 PAINTING

4A.4.12.1 General Requirements

Painting and protection of materials shall be in accordance with the technical specifications.

All colour schemes shall be established by the Contractor and subject to the approval of the Engineer. They shall be the same as those used by MEW on existing water transmission systems.

4A.4.12.2 Coatings in Contact with Drinking Water

All coatings in contact with drinking water shall comply with the latest requirements of the UK Water Supply (Water Quality) Regulations Nos. 25 and 26 (as published on the WDI website: www.dwi.detr.gov.uk.) or shall be to the approval of the American Food and Drug Association, or equivalent internationally recognised body. An appropriate certificate of compliance shall be submitted to the Engineer for his approval.

Unless otherwise approved by the Engineer, all coating materials to be applied to a particular item shall be obtained from the same manufacturer.

--- END OF SECTION ---

MINISTRY OF ELECTRICITY AND WATER

WATER PROJECTS SECTOR

CONSTRUCTION AND MAINTENANCE OF 5 NOS. R.C. GROUND RESERVOIRS FOR FRESH WATER, 55 M.I.G CAPACITY EACH, AND ANNEXED WORKS AT MUTLA HIGH (STAGE-II)

SECTION 4A.5

SPECIFICATIONS OF EARTHWORKS

CONTENTS

4A.5 EARTHWORKS

4A.5.1 SCOPE

4A.5.1.1 General

This Part of the Specification covers the requirements for earthworks including site clearance, general excavation, trench excavation, filling, embankments, top soiling and reinstatement.

4A.5.1.2 Definitions

The following terms shall have the meanings hereby assigned to them: -

Earth - shall mean all materials encountered in excavations including rock and artificial material.

Unsuitable - shall mean material unsuitable for reuse in filling. Unsuitable material shall be removed off site and disposed of.

Selected excavated material - shall mean material which is selected from excavations, including borrow excavation if necessary, which is suitable for use as fill material and shall include material which is made suitable by processing including grading and adjustment of moisture contents.

Bulk fill -shall mean general fill and fill in embankments to levels and grades as specified on the drawings.

Structural fill - shall mean bulk fill and fill placed in embankments or other areas of fill which is specified to be compacted to a high standard of compaction.

Backfill - means backfill with selected excavated material into excavations including trenches and around structures.

Disposal - shall mean disposal off site.

Services - shall mean all buried or above ground services including pipes, cables, drains, power lines, oil pipelines and their appurtenances, supporting structures and the like.

Obstructions - shall include all buried or above ground obstructions including services, fences, street furniture, marker posts, buried chambers, anchor blocks, supports and the like.

Formation - shall mean the final surface upon which or against which fill or structures are to be constructed.

Excess excavation - shall mean excavation beyond the lines and levels shown on the drawings or specified.

4A.5.2 REFERENCE STANDARDS

Unless otherwise specified earthworks shall comply with relevant statutory regulations and Reference Standards.

Reference Standards are referred to in the text of the Specification in abbreviated form (e.g. BS 812). The full titles of some which have relevance to this part of the Specification are given below for convenience:

ASTM 2487	Test method for classification of soils for engineering purposes.
ASTM A975-97	Standard specification for double-twisted hexagonal mesh gabions and revet mattresses (metallic-coated steel wire or steel wire with coated polyvinyl chloride (PVC).
ASTM D 1556-90	Test Method for density and unit weight of soil in place by the sandcone method.
ASTM D 1557-91	Test method for laboratory compaction characteristics of soils using modified effort (56.000 ft-lbf/ft^3) (2,700 KN-m/m^3).
ASTM D 4253-91	Test method for maximum index density and unit weight of soils using a vibratory table.
ASTM D 4254-91	Test method for maximum index density and unit weight of soils and calculation of relative density.
ASTM D 698-91	Test method for laboratory compaction characteristics of soil using standard effort (12,4000 ft-lbf/ft^3) (600 KN-m/m^3).
BS 1052	Specification for mild steel wire for general engineering.
BS 1377	Methods of test for soils for civil engineering purposes.
BS 443	Specification for testing zinc coatings on steel wire and for quality requirements.
BS 6031	Code of practice for earthworks.
BS 6187	Code of practice for demolition.
BS 6906	Methods of test for geotextiles
BS 812	Testing aggregates.
CIRIA Report 97	Trenching practice.

If no standard is specified, the relevant British Standard shall apply.

4A.5.3 SUBMISSIONS BY THE CONTRACTOR

Submissions by the Contractor shall include the following;

- Survey Drawings showing the ground levels prior to the start of any earthwork and surveys taken for the purposes of measurement of quantities of excavation or filling;
- Information obtained from any trial hole;
- Field measurement of excavations;
- Samples;
- Certified results of laboratory and field tests including, but not limited to, compaction records, in-situ density tests, compaction tests, in-situ soil strength tests, particle size distributions and chemical analysis;
- Method statements for excavation and filling, stock piling, transporting, dealing with water, testing, compaction, processing and reinstatement including;
- Details of any proposals and sources of imported fill;
- Methods of fill from excavated material;
- Methods of processing fill to achieve quality requirements particularly in respect of moisture content and compaction;
- Proposals for quality control, proposals for laboratory testing and use of off Site laboratories.

4A.5.4 EXISTING CONDITIONS

4A.5.4.1 General

The Contractor shall have inspected the site and shall have undertaken all investigations necessary to satisfy himself of the site conditions prior to submitting his tender. The Contractors pre tender investigations shall be deemed to have determined:

- Excavation conditions including volumes of hard material, rock and artificial material;
- Locations, depths and volumes of unsuitable material;
- Sources of fill material and any processing requirements necessary to render excavated material suitable for use as fill material;
- Volumes of disposal and locations of disposal sites;
- Locations of services, obstructions and existing structures and requirements for supports and protection to same;
- Stability of excavations and fill slopes;

- Temporary work requirements;
- Compaction characteristics, processing requirements and construction plant and construction methodologies necessary to meet the specified requirements.

4A.5.4.2 Record Drawings

Before commencing any excavation in the vicinity of any existing works the Contractor shall obtain as built and record drawings of the existing works and shall make all necessary investigations including hand excavations to confirm the true extent and nature of the existing works.

No warranty shall be given as to the accuracy of any data or drawing concerning existing works.

4A.5.4.3 Existing Structures, Pipes and Services

Existing structures, pipes and services shown on the Drawings are provided to the Contractor in good faith without warranty as to their completeness or accuracy. The Contractor shall make all further investigations; hand excavations and surveys as are necessary to locate and identify the nature of all buried obstructions.

Before excavating near any existing structure pipe or service the Contractor shall notify the owner and obtain the owner's consent.

The Contractor shall programme and co-ordinate the Work at existing WDC's with the Employers Operation and Maintenance Engineers and shall comply with their requirements.

4A.5.4.4 Work in the vicinity of Structures, Pipes and Services

Excavation, filling and other work within the vicinity of existing structures, pipes and services shall be undertaken in accordance with the owner's requirements and the Engineer's instructions.

The Contractor shall indemnify and save harmless the Employer against any damage, due to the Contractor's construction activities, caused to any structures, pipes or services.

4A.5.4.5 Uncharted Obstruction and Services

The Contractor shall immediately notify the Engineer of any uncharted or incorrectly charted pipes or services encountered during excavation and shall cease all mechanical excavation in the vicinity of the uncharted obstruction.

4A.5.4.6 Protection

The Contractor shall safeguard, support and protect from damage or movement all existing services, pipes and structures encountered which are to remain in service.

All protection works shall be designed and constructed in accordance with the owner's requirements and to the approval of the Engineer.

4A.5.4.7 Abandoned Services

Within the limits of excavation the Contractor shall remove existing pipes, sub-soil drainage systems, conduits, manholes and related items that are to be abandoned and shall plug open ends with concrete.

4A.5.4.8 Existing Structures and Thrust Restraints

The Contractor shall execute the Works in such a manner as to ensure that no damage occurs to adjoining property, roads or structures.

The Contractor shall assess the effects of excavation on existing structures and thrust restraints to existing pipelines and shall provide all necessary props and temporary shoring to prevent lateral yield of the soils and loss of foundation support.

4A.5.4.9 Levels to be recorded

The Contractor shall satisfy himself as to the accuracy of the levels and shall agree any necessary changes with the Engineer before the surface of the Site is disturbed.

Where levels are not shown the Contractor shall conduct a survey and agree the commencement levels before disturbing the existing ground.

The Contractor shall submit and agree all measurements with the Engineer as the work proceeds. In the event of any surface being disturbed or covered prior to the agreement of the measurement by the Engineer the Engineer will assess the measurement.

The Contractor shall ensure that the levels and dimensions of all pipes, structures and services are accurately recorded for the production of the Record Drawings and shall re-excavate any work where levels and dimensions have, in the opinion of the Engineer, not been accurately recorded.

4A.5.4.10 Survey and Measurement

Survey record drawings shall be submitted within seven days of the completion of the survey. No earthworks shall be started until the original levels and conditions have been agreed with the Engineer.

4A.5.5 SAFETY AND AVOIDANCE OF NUISANCE

The Contractor shall:

- Perform all work in such a manner as to ensure the safety of the Works, the public and adjoining sites and so as to cause as little inconvenience as possible to the public and adjoining owners;
- Provide temporary barriers and lighting around the edge of all excavations;
- Provide all necessary temporary supports and safe means of access to excavations;

- Keep stores and material away from the edge of excavations so as to allow free movement of labourers and staff around the excavations;
- No length of Trench Excavation shall be commenced until suitable temporary fencing has been erected around that length unless the Engineer permits otherwise. Temporary fencing shall not be removed without permission, which will not normally be given until the Trench Excavation has been refilled and reinstated.

4A.5.5.1 Hedges, Fences and Walls

Where barriers such as hedges, fences and walls are temporarily removed the Contractor shall install and maintain temporary fencing as necessary or as instructed by the Engineer.

4A.5.6 FILL & PIPE BEDDING AND SURROUND MATERIALS

4A.5.6.1 General

Wherever possible fill and pipe bedding and surround material shall be obtained from the excavations. Where necessary the excavated materials shall be screened or processed to comply with the specification. Where there is insufficient excavated material, or the excavated material is unsuitable, and it cannot be processed to be made suitable, then the Contractor shall provide suitable material from an approved source.

Fill and pipe bedding and surround materials shall not contain ashes, cinder, refuse, rubbish, organic material or the like and shall be free from clods & lumps. The material shall fall within the following Standard Classifications:

	AASHTO	**BSCS**
Marine Sands	A 3	SP
Gatch	A1 / A-2-4	SW, SM
Granular	A1 / A-2-4	GW, GP, SW, SP

Sabkha falling within the AASHO classification A4 & A6 and BSCS classification ML, CH, CL or MH shall not be used as pipe bedding and surround or fill material.

4A.5.6.2 Pipe Bedding and Surround

Pipe bedding and surround material shall be formed from hard dense granular material. It shall be selected to meet the specified requirements and the particular trench conditions and shall be inert to the groundwater or stored water and shall contain less than 20% (by volume) of calcium carbonate.

The material shall be free from clay with a liquid limit exceeding 80 or plasticity index exceeding 55 and be free from sharp particles which could cause damage to the pipe protection.

Materials shall be tested in accordance with BS 812-Part III, Section 8 and shall have a 10% fines value greater than 50kN. Material retained on a 7mm sieve shall have an index of flakiness less than 25% and an index of elongation less than 45%.

Pipe bedding and surround material shall be either Type I or Type II, at locations as shown on the drawings, and shall be excavated material selected and screened as necessary to comply with the grading limits specified in the following Table:

Table A

Grading of Pipe Bedding and Surround Material

BS Sieve (mm)	Percentage by mass passing sieve size Type I	Percentage by mass passing sieve size Type II
300		
200		
150		
125		
90		
75		
28		
20		90
14	90	85 – 90
10	10-90	50 – 85
5	0-90	20 - 40
2		5 - 20
0.6	0-90	0 - 5
0.2		
0.063	0-10	
0.002	0	

Type II material for pipe bedding and surround can also be 14mm single size gravel (imported) free from dust and material passing a 0.2mm size.

4A.5.6.3 Fill to Structures and Trench Backfill

Type A fill material complying with the particle size distribution shown in the following Table (Table B) shall be used as fill to structures and as backfill to trenches. With the approval of the Engineer fill containing larger sized material may be permitted in large volumes of fill subject to the material grading being such that it can be compacted without the formation of any voids and subject to a minimum clearance of 500mm between the oversized fill material and any structure or pipe or service.

Table B

Grading of Fill Materials – Type A Fill or Cement Stabilised Fill

BS Sieve (mm)	Percentage by mass passing sieve size
300	
200	
150	
125	90
90	
75	60-90
28	
14	10-90
10	0-90
5	
2	
0.6	0-90
0.2	0-80
0.063	0-10
0.002	0

4A.5.6.4 Cement Stabilised Fill

Cement stabilised fill shall be formed by mixing sulphate resisting cement with selected excavated material complying with the particle size distribution shown in Table B.

The quantity of cement, measured as a percentage of its dry weight, shall be a minimum of 5%. The material shall be thoroughly mixed to ensure that the cement is uniformly distributed throughout the fill material.

The material shall be placed and compacted within 2 hours of mixing.

4A.5.6.5 Gabion Fill

Gabion Fill shall comply with the particle size distribution shown in Table C and have a 10% fines value greater than 50kN determined in accordance with BS812 with samples in a soaked condition.

The Contractor shall submit details of the proposed source including certified test results and samples for the approval of the Engineer.

Table C

Grading of Fill Materials – Gabion Fill

BS Sieve (mm)	Percentage by mass passing sieve size
300	
200	
150	90
125	
90	0-10
75	
28	
14	
10	
5	
2	0
0.6	
0.2	
0.063	
0.002	

4A.5.6.6 Topsoil

Topsoil shall be obtained from excavations or imported and shall confirm to the grading and chemical characteristics specified in the following tables:

Table D

Topsoil Physical Grading

Material passing a No. 10 sieve	90%
Material passing a No. 35 sieve	90-90%
Material passing a No.140 sieve	0-10%
Material passing a No.270 sieve	0-3%

Table E

Topsoil Chemical Characteristics

Salinity (Ece x 900)	Less than 2
SAR (Sodium Adsorption Ratio)	Less than 1
Boron (saturation extract)	Less than 0.5pm
PH	Less than 8.0

4A.5.6.7 Backfilling to Structures

Valve chambers, thrust blocks and other structures shall be backfilled compacted with selected excavated material complying with clause 4A.5.6.3

Backfill and fill to shall be compacted at a moisture content within the range of three per cent (3%) below optimum to optimum, to not less than 95% of the maximum dry density obtained in the BS Compaction test described in Clause 3.3 of BS1377: Part 4: 1990.

Backfill to structures shall only be undertaken when the structure as developed sufficient strength.

Compaction plant operated adjacent to structures shall not overstress or cause damage to the structure. The material shall be placed and compacted uniformly in such a manner as to avoid eccentric or differential loads.

4A.5.6.8 Pipe Bedding and Surround

Pipe bedding and surround to pipes shall be carried out with material complying with clause 4A.5.6.2.

Pipe bedding and surround shall be compacted at a moisture content within the range of four per cent (4%) below optimum to optimum to not less than 90% of the maximum dry density obtained in the BS Compaction described in Clause 3.3 of BS1377: Part 4: 1990.

Heavy mechanical compactors shall not be used within 300mm of the pipe crown.

Pipe bedding shall be laid over the full width of the trench to provide a uniform bed for the pipes. The bedding shall be compacted to the correct levels and accurately shaped so that pipe is supported along the entire barrel length. The minimum thickness of the bed below the pipe barrel at any point shall not be less than that shown on the Drawings. The minimum thickness of bedding below joints shall be 50mm.

Recesses shall be formed in the bedding to accommodate joint and any specified wrapping.

Surround material shall be rammed and compacted in layers to a minimum depth of 300mmm above the pipe crown.

4A.5.6.9 Backfilling to Trenches

Trenches shall be backfilled with selected excavated material complying with clause 4A.5.6.3. The material shall be compacted at a moisture content within the range of four per cent (4%) below optimum to optimum in layers of between 90mm and 300mm thickness, to at least 90% of maximum dry density obtained in the BS Compaction described in Clause 3.3 of BS1377: Part 4: 1990. Trenches under access tracks and/or highway verges shall be compacted to 95% of the maximum dry density.

4A.5.6.10 Water

The contractor shall control the water content of all fill material as necessary to achieve the specified values of compaction.

Unless otherwise specified water used in earthworks may be fresh water or brackish water with a total dissolved solids content not exceeding 4500 parts per million.

4A.5.6.11 Gabions

Gabion boxes shall be manufactured from wire complying with BS 1052 having a minimum core diameter of 2.0mm. All wire shall be galvanized in compliance with BS443 and be coated with a minimum thickness of 0.55mm of PVC which shall be capable of resisting exposure to ultra violet light and abrasion, when tested for a period not less than 3000 hours in accordance with ASTM-G23-89.

The size of the mesh opening shall be no greater than 80mm.

4A.5.7 EXCAVATION

4A.5.7.1 General

Before commencing any excavation the limits of the excavation shall be accurately set out and the natural ground levels and condition shall be recorded and agreed with the Engineer.

4A.5.7.2 Site Clearance

All areas of the Site from which material is to be excavated or upon which filling (including spoil tips) is to be deposited shall be cleared to the extent required by the Engineer of all buildings, walls, gates, fences and other structures and obstructions and of all bushes, hedges, trees, stumps, roots and other vegetation except those identified for preservation.

Material not suitable for reuse shall be disposed of off the Site.

4A.5.7.3 Hedges and Trees

No trees or hedges shall be uprooted or cut down without prior approval of the Engineer.

4A.5.7.4 Stripping Top Surface

Where ordered by the Engineer the top surface including topsoil, organic or unsuitable founding material shall be stripped, to such depths and over such areas as the Engineer may direct, as a separate operation prior to any further excavation.

4A.5.7.5 Removal of unsuitable Material

Surface deposits of gypsum and salts shall be excavated and disposed of off Site.

The depths of excavation shall be as instructed by the Engineer.

Unsuitable materials shall not be allowed to contaminate suitable material.

4A.5.7.6 Excavation in any Material

Excavation shall be made in any material including rock to the required lines and levels.

The Contractor shall be deemed to have studied the site investigation data, visited the Site and collected all data necessary to evaluate the nature of the Site and shall be deemed to have included the costs of excavation in any material in his tender. No additional payments shall be made for excavation in rock, removal of boulders, excavation of loose sand or for excavation in any other materials whether natural or artificial.

4A.5.7.7 Excess Excavation

Excess excavation below pipes in trenches shall be pipe bedding or concrete as directed by the Engineer.

Where concrete is to be cast against undisturbed ground, Excess Excavation shall be backfilled with mass concrete of the same grade as specified for the structure.

Excess excavation around structures for working space shall be backfilled with approved compacted fill.

Excess excavation under roads and paved areas shall be backfilled with approved compacted fill or concrete as directed by the Engineer.

4A.5.7.8 Formations for Foundations and Embankments

Formations to receive foundations, road embankments, structural fill and cement stabilised fill shall be excavated to sound material with the bearing capacity as specified on the Drawings or as directed by the Engineer.

The Contractor shall inform the Engineer of any formation or material which he considers to be unsuitable.

4A.5.7.9 Formations for Ground Slabs, Paving and Compacted Embankments

The top 300 mm of the formation to receive ground slabs paving materials and compacted embankments shall be scarified watered and compacted to 95% of maximum density.

4A.5.7.10 Formations in Trenches

Any unsound material in the bottom of trenches shall be removed and the void filled with compacted bedding material or concrete Class C15 as directed by the Engineer.

All shattered and loose material shall be removed so that the bedding rests on a sound clean foundation.

Any rock or hard material shall be excavated to provide a minimum clearance around the pipe or service of at least 150mm. No rock, boulder, stone or hard material shall protrude into this minimum clearance.

4A.5.7.11 Trimming Excavations

Excavations for foundations or within which concrete is to be cast against undisturbed ground shall not be completed to the final level or profile until immediately before construction of the permanent works. A minimum of 90mm of excavation shall be left for final trimming.

Shattered and loose material shall be removed from the bottom of excavations.

4A.5.7.12 Explosives and Blasting

The use of explosives will not be permitted.

4A.5.7.13 Excavations - Support and Working Space

All excavations shall effectively supported to prevent any fall or run from any portion of the ground outside the excavation and to prevent settlement or damage to services or to structures adjacent to the excavation.

Temporary supports and the procedures for installing and withdrawing them shall generally comply with the requirements and recommendations of CIRIA Report 97.

Excavations with sloping faces, without shoring, shall be to stable slopes and heights.

No excavations with battered sides will be permitted in public highways or within 30 metres of any building or other structure.

Details and calculations for supports and temporary slopes shall be submitted to the Engineer for approval.

4A.5.7.14 Wind Blown Sand

Wind-blown sand deposits and accumulated materials shall be removed from excavations.

4A.5.7.15 Trench Widths

Maximum trench widths shall be as shown on the Drawings or if no dimensions are shown the width shall be the minimum necessary for the installation of the pipe or service.

In the event of any trench exceeding the specified width the Engineer may order the use of an alternative type of bedding and fill or such other remedial measures as in his opinion are necessary.

Where any trench for a pipeline is excavated with battered or stepped sides, the bottom of the trench from the formation to a point 300mm above the crown of the pipe shall be formed with vertical sides at the maximum widths.

4A.5.7.16 Dewatering Excavations

Excavations shall be kept free from water whether emanating from rainwater, surface runoff, groundwater or other sources such that the works are constructed in dry conditions.

All necessary measures shall be taken to prevent ingress of water to excavations from surface rainwater runoff.

Any foundation material rendered unsuitable by water or exposure shall be removed and replaced with mass concrete.

Where required, dewatering shall be maintained for as long as necessary to prevent flotation of any pipes or structures.

Disposal of water shall be to the Engineer's approval.

4A.5.7.17 Disposal of Excavated Material off the Site

Excavated material shall, as far as possible, be re-used in fill.

All surplus and unsuitable material shall be removed from the Site and disposed of.

The Contractor shall identify suitable sites for disposal and obtain all necessary permissions and permits from the Municipality, other relevant authorities, owners or occupiers and the approval of the Engineer.

Disposal shall not create a nuisance or interfere with, or obstruct, or endanger, or contaminate any property or sources of water.

Disposal sites shall be graded and shaped to harmonise with their surroundings and shall comply with the requirements and regulations of any planning, health, or other authority having an interest therein.

4A.5.7.18 Temporary Spoil Tips

Temporary spoil tips shall be so shaped as to maintain stability and good drainage at all times, and shall not result in the deposition of wind blown sand across the Site or a nuisance to areas outside of the Site. The limits of temporary spoil tips shall be to the Approval of the Engineer.

4A.5.7.19 Fossils and Antiquities

The Contractor shall immediately cease work, other than any works necessary for safety and protection and shall inform the Engineer of any fossils, coins, articles of value or antiquity, or anything of geological or archaeological interest found.

4A.5.7.20 Inspection by the Engineer

When the specified levels or limits of any excavation are reached, the Engineer will inspect the formation and if he considers that any part of the ground is unsuitable he will direct the Contractor to excavate further and backfill to the specified levels or limits with concrete, compacted pipe bedding material or compacted fill.

Should the material forming the bottom or side of any excavation become unacceptable due to exposure to weather conditions or due to flooding or have become puddled, or soft or loose or otherwise become unsuitable during the progress of the Works, then the Contractor shall re-excavate and fill to the approval of the Engineer.

4A.5.7.21 Trenches not to be left open

No length of trench shall be excavated until the pipes are available on the Site.

Trench Excavation shall be carried out expeditiously and, subject to any specific requirements of the Contract, the refilling and surface reinstatement of Trench Excavations shall be commenced and completed as soon as reasonably practicable after the pipes have been laid, jointed and tested.

No more than 5km of excavated trench shall be excavated ahead of pipe laying and no more than 5km of excavated trench shall remain open behind the laid pipes.

The Contractor shall prevent flotation of pipes in locations where the open trench may be flooded. The precautions may include the partial refilling of the trench leaving pipe joints exposed for testing of the joints.

The number of work fronts and length of trench open at any time shall be subject to the approval of the Engineer.

The Engineer may prohibit further trench excavation until he is satisfied with the progress of laying and testing and backfilling in the ongoing work areas.

4A.5.8 FILLING

4A.5.8.1 General

Fill material shall generally be obtained from excavations and shall comply with clause 4A.5.6. Where there is insufficient suitable excavated material for filling the Contractor shall:

(a) Carry out such work as may be necessary to sieve or otherwise render the excavated material suitable, or

(b) Transport suitable material from excavations elsewhere ('overhaul'), or

(c) Excavate and transport material from suitable borrow areas.

(d) Import suitable material.

Processing, overhaul and import of materials shall be subject to the approval of the Engineer and shall be at no additional cost to the Employer.

Approval of the proposed surface shall be obtained prior to the Contractor placing fill on a previously compacted area. The Contractor shall carry out all necessary remedial work promptly as directed by and to the approval of the Engineer.

Filling shall proceed in such a manner that there is always a general fall across the filling surface towards the lower contours.

Any material not complying with the specified density or moisture content shall be removed from the fill notwithstanding the fact that it may have been covered by subsequent layers of fill or concrete.

When the weather is such that in the opinion of the Engineer it would adversely affect the placing of fill, all filling shall be stopped. In wet weather fill material shall be so placed as to maintain adequate drainage and to prevent accumulation of water

4A.5.8.2 Placing Fill

The Contractor shall ensure that a good bond is achieved between layers of fill, and unless otherwise directed by the Engineer, no material shall be placed on previously compacted layers until the surface has been harrowed or otherwise broken up and, if necessary, watered. Any condemned material shall be removed.

The moisture content of compacted material shall be controlled within the range specified by either drying or adding water. The material shall be thoroughly mixed to ensure the moisture content is uniform.

4A.5.8.3 Placing, Mixing and Compaction of Cement Stabilised Fill

Cement stabilisation shall not be carried out during periods of rain or when rain is imminent. During processing only sufficient water shall be available in the material to hydrate the cement and enable satisfactory mixing and compaction to be achieved. Any added water shall be fresh water of potable quality and shall be applied uniformly and thoroughly mixed by appropriate means.

Each layer of stabilised material shall be compacted as soon as possible after laying and in any case within 2 hours following the mixing of the cement into the material to be stabilised. Compaction shall be carried out by a minimum of 5 passes of a 3 tonne vibratory roller. The compacted layer shall not be greater than 150mm in thickness. Other methods of compaction may be acceptable, subject to approval by the Engineer.

4A.5.8.4 Road Crossings

At Road crossings the pipe bedding and surround shall be type B material. The trench backfill shall be compacted in accordance with the requirements of the Ministry of Public Works to at least 98% maximum dry density.

Where directed by the Engineer trenches shall be filled with concrete.

4A.5.9 GABION UNIT CONSTRUCTION

Gabion units shall be assembled in accordance with the manufacturer's instructions and shall be sufficiently filled with Gabion Fill to allow for settlement. Gabion units shall be maintained square and with vertical sides. Internal tie wires shall be inserted and units shall be tensioned in accordance with the manufacturer's instructions. Gabion units shall be constructed so as to maintain tightness of mesh and shall be laced securely with Gabion Mesh wire. Mechanical equipment may only be used for filling gabion units where the Engineer is satisfied that the results are equivalent to filling by hand.

4A.5.10 REINSTATEMENT

4A.5.10.1 Tolerances

The Contractor shall make due allowance and shall correct any overbuild or settlement such that the finished levels at the end of the Maintenance Period comply with the Contract.

Embankments shall be overbuilt by a horizontal distance of not less than 300mm, and shall then be trimmed to the final profile.

4A.5.10.2 Hedges, Fences and Walls

The Contractor shall permanently reinstate all barriers.

In the case of a hedge the section removed shall be replaced by quicksets of the appropriate variety and where ordered by the Engineer the quickset shall be protected on one or both sides by an adequate post and barbed wire fence. During the Period of Maintenance all hedges shall be inspected and any dead bushes shall be replaced.

4A.5.10.3 Reinstatement of Trenches

Reinstatement of trenches shall be completed within three weeks of backfilling.

4A.5.10.4 Reinstatement of Roads

All permanent and temporary reinstatement of roads shall be constructed generally in accordance with Sections I, II, III and IV of the Technical General Specification for Roads and Drainage, Ministry of Public Works (MPW), Government of Kuwait with the following qualifications:

Reinstatement shall be to a standard at least equal to that immediately before the Contractor first entered thereon.

Road sub-base shall comprise natural mineral material conforming to gradation type C as defined in Clause 301.4.

Road base shall be a sand asphalt mix type A as defined in Clause 302.03.

Asphaltic surfacing shall comprise a base course of asphaltic concrete type I and a wearing course of asphaltic concrete type III as defined in Clause 401.03.

The base course shall be applied, spread and compacted in one layer of shingle sand bonding material mix in accordance with the Ministry of Public Work's Specification. (Mix 30% and 70% shingle). The minimum compaction density shall be 95% AASHO. The thickness of base course shall be the same as the base course of the existing road (150mm. minimum).

On the surface of the previous base course the Contractor is required to supply, heat and spray under pressure at the rate of 1½ Kg/m^2 a prime coat for bonding new surfaces with the old one.

On main roads the Contractor is required to supply, spread and compact one layer of a second asphaltic base course of minimum thickness of 90mm. The mix shall be in accordance with MPW Specification.

The Contractor shall supply, spread and compact a layer of asphaltic concrete mix as a wearing surface of 60mm thick for main roads for 40mm thick for secondary roads.

After the certification by the Engineer of completion of the work, the Contractor shall, unless it is otherwise stipulated by the Engineer, maintain the surface of paved trenches and adjacent curbs and gutters, side walks, fences, sod and other disturbed surfaces for a period of three months thereafter. The Contractor shall maintain for 6 months areas that have been paved and sidewalk tiles that have been replaced. All material and labour required for the maintenance of the trench surfaces and structures shall be supplied by the Contractor, and the maintenance shall be done in a manner satisfactory to the Engineer.

4A.5.11 QUALITY CONTROL

4A.5.11.1 Method Statements and Trial Sections

Before commencing earthworks the Contractor shall submit details of his proposed method of working. The details shall include methods and equipment proposed for installation of pipes and for selection, placing and compaction of pipe bedding, surround and backfill and methods of trench support. The proposals shall be demonstrated by constructing a trial length of pipeline.

Tests shall be made on the bedding and pipe surround material including moisture content, grading and density tests as directed by the Engineer. The trials shall include the placing of material in different layer thickness at moisture contents varying each side of optimum and with various compactive efforts applied so that the sensitivity of the technique adopted to slight variations from the intended procedure may be established.

4A.5.12 TESTING

4A.5.12.1 General

The Contractor shall carry out field and laboratory tests to ensure that fill complies with the specification and is placed and compacted in accordance with the Specification. Tests shall included measurements of grading and plasticity index (compaction within the specified limits of dry density and compacted at moisture contents).

Testing shall be to BS 1377:Parts 1 to 9, 1990 unless otherwise approved.

Particle size distribution (grading) shall be determined by the appropriate variation of Method 9 of BS 1377:Part 2, 1990.

Maximum dry densities and optimum moisture contents for compaction control by relative compaction shall be derived using either Method 3.3 or Method 3.4, as appropriate, of BS 1377: Part 4, 1990.

In-situ density shall be determined by the sand replacement method generally in accordance with Method 2.2 of BS 1377: Part 9, 1990 or a similar approved test.

Nuclear density testing equipment may be used in place of the sand replacement tests providing that:

The Contractor is able to demonstrate to the approval of the Engineer over a reasonable period that the results obtained with nuclear density equipment correspond with results obtained at the same time using sand replacement methods.

At least one sand replacement test is carried out for every ten nuclear density tests to check that the nuclear density equipment is properly calibrated and continuing to provide accurate results. The Engineer may at any time withdraw approval to use nuclear density testing equipment should there be any doubt as to the accuracy of results obtained.

The location of each field test or sampling point shall be to the approval of the Engineer. The location of each test shall be properly recorded and copies of the records shall be submitted to the Engineer weekly. Compaction test results and calculations shall be submitted at least 5 working days before placement and compaction of the respective material.

4A.5.12.2 Frequency of Testing

Testing of suitability of Excavated Materials.

At least one sample shall be taken for natural moisture content tests, plasticity index, particle size distribution and compaction testing from each 900m^3 of potential fill material. Additional samples shall be taken as necessary where the excavated material shows variation over the length and/or depth of the excavation.

4A.5.12.3 Testing of Fill

In-situ density and in-situ moisture content testing of Pipe Bedding & Surround Fill and Trench Fill shall be performed at the rate of one test per layer per 90m length of trench. If the first time pass rate exceeds 80% the frequency may be reduced to one test per layer per 200m length of trench. If the first time pass rate exceeds 90% the frequency may be reduced to one test per layer per 400m of trench, subject to the approval of the Engineer.

In-situ density and in-situ moisture content testing of backfill to structures shall be performed at a rate of one test per $90m^3$ One sample for laboratory compaction testing shall be taken from the placed fill for control testing at the rate of one sample per $5000m^3$ of fill. The sample location shall be as directed by the Engineer.

--- END OF SECTION ---

MINISTRY OF ELECTRICITY AND WATER

WATER PROJECTS SECTOR

CONSTRUCTION AND MAINTENANCE OF 5 NOS. R.C. GROUND RESERVOIRS FOR FRESH WATER, 55 M.I.G CAPACITY EACH, AND ANNEXED WORKS AT MUTLA HIGH (STAGE-II)

SECTION-4A.6

SPECIFICATIONS OF METALWORKS

CONTENTS

4A.6 METALWORK

4A.6.1 SCOPE

This part covers the supply, fabrication and installation of metalwork including ladders and access covers.

4A.6.2 REFERENCE STANDARDS

Metalwork shall comply with the relevant statutory regulations and Reference Standards unless otherwise indicated within this Specification. In general the following shall apply:

a) British Standards and British Standard Codes of Practice;

BS 970 - Wrought steels

BS 4211 - Specification for ladders

BS5834 - Surface boxes

BS6180 - Barriers

BS 4190 - Bolts

b) If no standard is specified any internationally recognised standard such as British Standards (BS), DIN, ASTM, ASME, AWWA etc. shall apply.

4A.6.3 Submissions by the Contractor

Submittals made by the Contractor shall include but not be limited to the following:

Drawings:

a) General arrangement;

b) Detailed manufacturing shop drawings.

Certificates:

a) Material tests;

b) Data;

c) Manufacturers' catalogues (where alternatives are offered for approval);

d) Manufacturers’ catalogues and test data for proprietary fixing bolts.

4A.6.4 GENERAL

The Contractor shall supply and install all items of metalwork as shown on the Drawings, Specified, or necessary for the satisfactory completion of the Works, together with all fixings, mounting brackets, locking screws, lifting keys and other accessories necessary for erection, permanent fixing and operation.

The Contractor shall carry out the detailed design of all metalwork. Unless otherwise specified or shown on the drawings metalwork fabrications shall comply with the requirements of this Part of the Specification.

No orders for engineering metalwork shall be placed by the Contractor until he has submitted his detailed drawings, and where applicable supporting design calculations, to the Engineer and received the Engineer's consent.

Where the Contractor proposes to use dissimilar metals either in contact or close enough for the gap between them to be bridged by an electrolyte, he shall satisfy the Engineer that adequate anti-corrosion provision is included in the design.

4A.6.5 MATERIALS

4A.6.5.1 Steel Items - General

Unless otherwise specified all steel items and steelwork including bolts and fixings shall be Stainless Steel Grade 316L to BS 970

4A.6.5.2 Aluminium Items - General

Items of aluminium and aluminium alloy shall comply with the relevant provisions of BS 1470, BS 1471 and BS 1474.

4A.6.5.3 Steel Ladders

Steel ladders shall be generally in accordance with BS 4211 for Class A ladders with solid steel stringers (stiles) but shall have the following dimensions:

Minimum size of stringer	-	65 x l2mm
Diameter of rungs	-	25mm
Rung spacing	-	300mm
Rung length between stringers	-	400mm
Minimum clearance to wall or other obstruction	-	220mm
Maximum distance between stringer supports	-	1.5m

Rungs shall be able to withstand a point load of at least 500N when applied at any point along the rung and shall be a minimum of 200mm clear off the wall.

Wherever possible, stringers shall extend 1.0m above the level of the floor or platform at the top of the ladder and the clear width between stringers shall be increased to 600mm for this length.

The stringers shall be sized to suit the height of ladder and the intervals of the stringer supports. Stringers shall be drilled to receive the rungs, which will be welded to the stringers on each side of each stringer. Unless otherwise detailed on the Drawings the bottom ends of the stringers shall not be designed for floor fixing but shall terminate at wall fixing supports at least l50mm above the floor. All edges of stringers, brackets, splice plates and other components shall be ground smooth to remove burrs and sharp edges.

Ladders exceeding 4m high shall be provided with safety hoops at intervals not exceeding 900mm, with the lowest hoop 2.5m above the floor unless otherwise specified or shown on the Drawings. When detailed on the Drawings, anchorage points shall be provided for attaching safety harnesses instead of the above safety hoops.

Unless provided otherwise, landings of open mesh flooring and handrails shall be provided at intervals not greater than 9m.

4A.6.5.4 Manhole and Chamber Steps (step irons)

Manhole step irons shall be stainless steel grade 316 S16 to BS 970. The shape and dimensions shall be to the figure of BS 1247 as follows:

- Steps in brickwork or in-situ concrete manholes: - Figure 1
- Steps in pre-cast concrete manholes: - Figure 2

Where the thickness of the structure permits, the larger tail dimensions in Figures 1 and 2 shall be used.

Manufacturers' certificates shall be provided for all manhole step irons.

Step irons are to be positioned in the concrete walls in such manner that the step irons are in line vertically. The joints at each step iron shall be made watertight and strong, free from cracks and if found otherwise the Engineer will reject the work. The first step iron shall be fixed adjacent to and below the access cover level and the last step iron shall be fixed at a maximum of 250mm from the top level of the lowest adjacent finished base slab level. Step irons shall be staggered at 250mm centres vertically and 300mm horizontally.

4A.6.5.5 Access Covers, Road Gully Gratings and Frames

Access covers, road gully gratings and frames shall be of ductile iron and shall comply with BS 497: Part 1. Lockable units shall be provided where instructed by the Engineer.

Sealed covers and frames shall incorporate suitable neoprene or other approved synthetic rubber sealing rings, or shall seal by another approved sealing method.

4A.6.5.6 Surface Boxes

Surface boxes for key operation of valves and sluice gates shall be of grey or ductile iron and shall comply with the relevant requirements of BS 5834: Part 2. They shall be Grade A and coated.

4A.6.5.7 Metal Flooring and Walkways

Metal flooring and walkways shall comply with BS 4592, Part 1, 2 or 3 as appropriate and shall be:

- Of stainless steel or aluminium;
- Heavy Duty;
- Of open bar gratings, expanded metal grating panels or cold formed planks;
- Pressed bar construction shall not be used.

Flooring, walkways and supporting members shall be designed for a loading of $7.5kN/m^2$ of plan area and shall be removable. The maximum weight of each panel shall not exceed 25kg. Removable sections of flooring shall be provided with holes for lifting keys and keys to suit.

Flooring shall be detailed and fabricated so that no cutting is required on Site.

Bolt holes in brackets and mountings shall be slotted to allow for adjustment of line and level. Cut-outs shall be trimmed with straight or curved bars as appropriate. Angle kerbing for seating the flooring in concrete shall be provided. Kerbing and other supporting structures for building into concrete shall have lugs welded on at maximum spacing of 600mm.

The clear width of any access walkway shall be not less than 600mm.

All members of assemblies shall be marked at the factory with distinguishing numbers, letters or marks corresponding to those shown on approved drawings or parts lists.

4A.6.5.8 Chequer Plate

Chequer plate flooring shall have a raised pattern without enclosed recesses and shall have a minimum base thickness of 4.5mm in the case of steel plate or 8mm in the case of aluminium. Panels shall be secured to supports with countersunk screws at maximum spacings of l.0m along supports.

Chequer plating shall be suitable to withstand a maximum intensity of distributed load of 7.5kN/m^2 with a deflection not exceeding 2% of the span.

4A.6.5.9 Handrailing

Metal handrailing shall comply with the relevant recommendations of BS 6180. Handrailing shall consist of standards at regular intervals not exceeding l.5m, and two rails. The upper rail shall be l.1m above the adjacent finished floor level and 0.9m above the nosing line on stairways. The lower rail shall be midway between floor or nosing line and the upper rail. Rails shall be fabricated from 40mm bore stainless steel tube and standards from 45mm diameter solid stainless steel bar.

Handrailing shall be designed to withstand a minimum horizontal force at handrail level of 740N per metre run. When a horizontal load of 360N per metre run is applied at handrail level the horizontal displacement of the handrailing at any point shall not exceed 1/125 of the distance between the centrelines of adjacent standards or 10mm whichever is the lesser.

Handrailing shall be ball-jointed. Handrailing terminating against a wall shall either have a suitable wall-fixing flange or shall terminate at a standard or a loop with a gap between the standard or loop and the wall not exceeding 75mm. Where the shape of the floor or platform structure does not incorporate an upstand at the edge of walkways, toe plates not less than 5mm thick and not less than l00mm high shall be fixed to the handrail standards. The bottom edge of such toe plates shall be not more than 25mm above the surface of the walkway.

The handrail standards for stairways and for landings and walkways of width less than l.2m shall have palm fittings for bolting to the sides of the structures. Elsewhere the standards shall be designed for fixing l00mm (minimum) inside the edge of concrete structures, or at the supporting edge girder of steel flooring, or have palm fittings. Standards either side of openings shall be equipped with eyes for attaching safety chains at top and middle rail level.

Safety chains shall be l0mm nominal size, short link, smooth welded chain in accordance with BS 4942, Part 2. Each length of chain shall be fitted with a shackle at one end and a snap fastening at the other. Safety chains shall be provided at the top of all ladders and staircases except where shown otherwise.

4A.6.5.10 Thrust Block Steel Beams

Steel beams for resisting pipeline testing and working forces at thrust blocks shall be European Wide Flange mild steel beams in accordance with Euronorm 53-62.

4A.6.5.11 Servicing Hooks

Servicing hooks shall comply with those provisions of BS 2903 which relate to the appropriate Type. Each hook, together with any beams and other supporting members, shall be designed (with an appropriate allowance for dynamic loading) to carry safely the heaviest item of plant that needs to be lifted.

The safe working load shall be clearly and permanently displayed alongside each hook so as to be legible from the normal working level.

4A.6.5.12 Fixings for Metalwork

Bolts for fixing metalwork to concrete, brickwork or blockwork shall be of the following types: -

- For fixing in drilled holes in horizontal, vertical or inclined surfaces, approved proprietary epoxy resin fixed bolts shall be used. The epoxy resin shall be a quick setting formulation, supplied in suitable premeasured sachets to separate the components until punctured in the hole and mixed by rotation of the fixing bolt. The resin and bolts shall be used in accordance with the manufacturer's instructions. When fixed, the resin shall completely fill the space between the bolt and the hole to the surface of the concrete, brickwork or blockwork.
- As an alternative to (a), approved mechanical expansion type bolts may be used for fixing to concrete surfaces inside buildings above ground level where the application proposed by the Contractor is approved by the Engineer. Expansion bolts shall not be used inside liquid retaining structures, in chambers, basements and similar locations below ground level, in exterior locations, or in any brickwork or blockwork.
    - For fixing to horizontal top surfaces of concrete by grouting with cement based grout or mortar, foundation bolts may be used in preformed, drilled or cut pockets,
    - Where approved by the Engineer, screws and approved fixing plugs.
    - The Contractor shall submit details of his proposed fixings for the approval of the Engineer. Where required by the Engineer the Contractor shall demonstrate the effectiveness of the fixings by suitable tests.

- Other bolts and nuts used in fabrication or erection shall be in accordance with BS 4l90.
- Bolts, nuts, screws, washers and other fixings shall be stainless steel in accordance with the provisions of the Specification and to match the item to be fixed.

4A.6.5.13 Opening Tools

Lifting keys and devices for unfastening locking screws shall be of galvanised mild steel. They shall be supplied at the rate of one set for each five similar covers, with a minimum of two sets of each particular type.

4A.6.6 WORKMANSHIP

4A.6.6.1 Tolerances

Metalwork shall be constructed and installed within the following tolerances:

a) Metalwork at floor level (e.g. joints between flooring sections and between steel flooring and adjacent concrete):

Difference in level at joints	-	3mm
Joint gap	-	3mm
Dimensions shown on Drawings	-	+/- 5mm
Levels shown on Drawings	-	+/- 5mm

4A.6.6.2 Installation

Where metalwork is to be founded on and/or fastened to concrete the Contractor shall use one of the following methods: -

1. Bolting or screwing the metalwork to plates or angle section having anchors cast into the concrete or set into pockets left in the concrete.
2. Setting the metalwork into pockets left in the concrete.
3. Bolting the metalwork to anchor bolts (studs) cast into the concrete or set into pockets left in the concrete.
4. Bolting the metalwork to anchor bolts (studs) set in holes drilled into the concrete.
5. Bedding the metalwork on cement mortar placed on the concrete surface.

Cement mortar of 3 parts of sand to l part of cement shall be used for bedding access covers and the like and for filling around metalwork or bolts set into pockets smaller than l00mm square or equivalent. For larger holes, concrete of the same grade as the structure shall be used.

The installation methods permitted for various types of metalwork are specified in Table 33A.

TABLE 33A

Metalwork items	Permissible methods of installation
Stairs, ladders, flooring	1, 3 and 4
Step irons, sockets for removable items	2
Handrailing	2, 3 and 4
Access covers, surface boxes and gully gratings	2 and 5

During installation each item of metalwork shall be temporarily braced as necessary to resist all forces which are likely to be applied to it during installation, fixing and building in. Bolted connections shall be fitted and tightened before fixing bolts are tightened or pockets are grouted. The nuts of grouted or resin fixed bolts shall not be tightened until the grout or resin has fully cured.

Where approved by the Engineer small or lightly loaded items may be fixed using screws and plugs set in drilled holes.

--- END OF SECTION ---

MINISTRY OF ELECTRICITY AND WATER

WATER PROJECTS SECTOR

CONSTRUCTION AND MAINTENANCE OF 5 NOS. R.C. GROUND RESERVOIRS FOR FRESH WATER, 55 M.I.G CAPACITY EACH, AND ANNEXED WORKS AT MUTLA HIGH (STAGE-II)

SECTION-4A.7 TO 4A.13

SPECIFICATIONS FOR

PIPELINES, CABLE DUCTS AND APPURTENANCES

CONTENTS

4A.7 PIPELINES

4A.7.1 SCOPE

This Part covers general requirements for pipes, valves and fittings and cable ducts.

Unless otherwise specified water pipelines and fittings shall be of ductile iron. Pipe joints shall be spigot and socket push in joints. Joints at fittings shall be flanged or (bolted gland) mechanical joints. Valves shall have flanged joints.

Cable ducts shall be high density polyethylene (HDPE) with push fit spigot and socket type joints

4A.7.2 DEFINITIONS

The following terms shall have the meanings hereby assigned to them: -

'Pipes'	Straight pipes, whether whole or cut and their joints.
'Pipeline' or 'Pipework'	The whole pipeline inclusive of pipes, fittings, valves and pipeline appurtenances.
'Fittings'	All components fitted to a pipe for jointing, connecting or changing the direction or bore of a pipe (including bends, tees, tapers, collars and couplings).
'Valves'	Valves installed on the pipeline including isolation valves and air valves.
'Pipeline appurtenances'	All items additional to pipes and fittings required to complete a pipeline including but not limited to internal and external protection systems, supports and anchors, chambers, marker posts and any apparatus or construction required for testing, cleaning, disinfecting or operating the pipeline.
'Ducts'	High Density Polyethylene Pipeline inclusive of all fittings and appurtenances including draw pits and draw cords.
'Accessories'	Nuts, bolts, gaskets, glands, lubricants and all other items necessary to lay and joint the pipework.

4A.7.3 SUBMISSIONS BY THE CONTRACTOR

4A.7.3.1 Drawings

Submissions by the Contractor shall include but will not be limited to the following:

- Typical drawings of standard items.

- Detail drawings of special items.
- Shop drawings for valve chambers and draw pits including:
  - Details of pipes and fittings.
  - Foundation and support details for pipes, valves and fittings.
  - Setting out dimensions.
  - Reinforcement details.
  - Metalwork and supports.
  - Valve spindle details.
  - Method of building pipes into structure walls.
- Pipeline plan and profile drawings.
- Details of supports to buried services.
- Temporary work details, including temporary supports.

4A.7.3.2 Data

Submissions by the Contractor shall include but will not be limited to the following:

- Pipe, fittings and joint details including manufacturer, pressure/temperature ratings, material properties and thickness and lubricants.
- Design details of any flanges outside the range of Reference Standards.
- External and internal protection and lining system details.
- Method for control of line and level of pipeline during installation.
- Manufacturers' calculations, catalogues and data sheets.
- Manufacturers' installation instructions.
- Constituents and properties of materials used in non-homogeneous pipe wall construction.
- Contractor's calculations for pipe and fitting design.
- Methods for pipe handling, installation and backfill.
- Details of pipeline insulation system.
- Materials of manufacture of valves – chemical composition of alloys and quality of metals used.
- Sealing arrangements of valves and seating designs.

- Valve Performance data.
- Evidence of satisfactory performance of valves.

4A.7.4 PRODUCTS IN CONTACT WITH WATER FOR DRINKING

The Contractor shall submit for the Engineer's approval, a schedule of substances and products he proposes to use in the Works which may come into contact with water supplied for drinking. The schedule shall include:

- Item description.
- Substance or product in contact with water.
- Manufacturer of substance or product.
- Location of point of use in the Works.
- Name of the regulatory body which has approved the substance or product for use in contact with potable water.
- Date of approval.
- Approval reference number.
- Details of any condition attached to the approval.

4A.7.5 REFERENCE STANDARDS

4A.7.5.1 Introduction

Unless otherwise specified materials and workmanship shall comply with the relevant American, British or other Reference Standard as listed below or stated within the specification clauses.

Where pipelines or any parts thereof are outside the range of sizes covered by Reference Standards, the requirements of the Reference Standards shall still apply where relevant, unless otherwise specified.

4A.7.5.2 Pipelines - General

AWWA C651	Standard for disinfecting water mains.
AWWA M12	Simplified procedures for water examination.
BS 1377	Methods of test for soils for civil engineering purposes.
BS 2494	Elastomeric seals for joints in pipework and pipelines.
BS 2569: Part 1	Sprayed metal coatings.
BS 3251	Indicator plates for fire hydrants and emergency water supplies.

BS 3927	Rigid phenolic foam (PF) for thermal insulation in the form of slabs and profiled sections.
BS 4190	ISO metric black hexagon bolts screws and nuts.
BS 4320	Metal washers for general engineering purposes. Metric series.
BS 4504: Part 3	Circular flanges for pipes, valves and fittings (PN-designated): steel, cast iron and copper alloy flanges.
BS 5292	Jointing materials and compounds for water, low pressure steam installations, 1st, 2nd and 3rd family gases.
BS 6076	Tubular polyethylene film for use as protective sleeving for buried iron pipes and fittings.
BS 6105	Corrosion-resistant stainless steel fasteners.
BS 6956: Part 5	Jointing materials and compounds: Jointing compounds for use with water, low pressure saturated steam, 1st family gases (excluding coal gas) and 2nd family gases.
BS 7079: Parts O & A1	Preparation of steel substrates before application of paints and related produces: Introduction and visual assessment of surface cleanliness.
BS 8010: Part 1	Pipelines on land: general.
BS 812: Part 103.1	Method for determination of particle-size distribution: sieve tests.
BS EN 1514	Flanges and their joints – Dimensions of gaskets for PN-designated flanges.
SIS 05-5900	Pictorial surface preparation standards for painting steel surfaces.
WIS 4-52-01	Polymeric anti-corrosion (barrier) coatings.

4A.7.5.3 Ductile Iron Pipes

AWWA C.105	Polyethylene Encasement for Ductile Iron Pipe Systems
AWWA C104/A21.4-95	Cement Mortar Lining for Ductile Iron Pipe and Fittings for Water.
AWWA C111/A21.11	Rubber Gasket Joints for Ductile Iron Pressure Pipes and Fittings.
AWWA C151/A21.51-96	Ductile Iron Pipe, Centrifugally Cast, for Water.

BS 2789	Spheroidal graphite or nodular graphite cast iron.
BS 3416	Bitumen-based coatings for cold application suitable for use in contact with potable water
BS 4027	Sulphate-resisting Portland cement.
BS 8010: Section 2.1	Pipelines on land: design, construction and installation: Ductile iron.
BS EN 22063	Metallic and other coatings. Thermal spraying. Zinc, aluminium and their alloys.
BS EN 545	Ductile iron pipes and fittings.
ISO 7005-2	Metallic Flanges – Part 2
ISO 2531	Ductile iron pipes, fittings and accessories for pressure pipelines.
ISO 8179	Ductile Iron Pipe – External Zinc Coating

4A.7.6 MATERIALS

4A.7.6.1 General

All items shall be of the diameter detailed in the Drawings and shall be suitable for the test and working pressures specified or detailed on the Drawings. The class and pressure rating shall not be less than that specified.

The normal temperature of the water in the pipelines will be up to 50ºC. All materials that are close to or in contact with the water shall be suitable for long-term exposure to such temperatures.

4A.7.6.2 Damage

No pipes or fitting with significant damage to the internal or external coatings will be accepted. Where in the opinion of the Engineer damage to the coating is minor, it shall be repaired as far as possible in accordance with the manufacturers recommendations to the original coating system. Acceptance of repairs will be subject to the satisfaction and approval of the Engineer. The Contractor shall be responsible for any repairs to be carried out on pipes purchased by the Contractor. All such repairs shall be carried out in the presence of an approved representative of the manufacturer.

No crack shall be allowed in the cement mortar lining of pipes and fittings.

4A.8 PIPES AND FITTINGS

4A.8.1 SCOPE

This part covers the supply and testing of pipes and fittings.

4A.8.2 MATERIALS

4A.8.2.1 Ductile Iron Pipes

Ductile iron pipes shall comply with ISO 2531 and shall have cement mortar lining to AWWA C104.

Pipes shall be manufactured by the centrifugal casting process with push-in socket and spigot joints The joints shall permit pipes to be deflected angularly by up to 2° axially for diameters up to 900mm and by up to 1.5° axially for diameters over 900mm.

Pipes shall be Class K9, unless otherwise specified or otherwise required to withstand the specified pressures. Pressure ratings of pipes (and fittings) shall be determined in accordance with BS EN545. Pipes shall be capable of sustaining the pressures detailed in BS8010 Part 2.1

Where pipes are specified to be “gauged” or “sized” they shall be suitable for cutting on site. Such pipes shall have the tolerance required on the external diameter to suit the joint applicable over the full length of the barrel. Such pipes shall be clearly marked “Gauged for cutting on site”.

4A.8.2.2 Ductile Iron Fittings

Ductile iron fittings should comply with ISO 2531 to withstand the specified pressures. Fittings shall be Class K12. Tees shall be Class K14. Fittings shall be capable of sustaining the pressures detailed in BS8010 Part 2.1

Spigot and socket joints shall be the mechanical (bolted gland) type supplied with rubber gasket and bolts. Glands should be ductile iron of the same quality as the fitting and shall be supplied with a bituminous coating of thickness not less then 100 microns. On a fixed spot on the outside of each gland the manufacturers name or identification mark, date of manufacture and nominal diameter shall be marked. Bolts for use with bolted gland joints shall be spheroidal graphite in accordance with BS 2789 Grade 500/7.

Self-anchored couplings and flange adapters shall not be used for transmission of axial loads.

4A.8.2.3 Marking Of Ductile Iron Pipes And Fittings

In addition to the requirements of ISO2531 each pipe and fitting shall be indelibly marked over any factory-applied coating with the letters M.E.W., the Contract number and a unique reference number to enable items to be correlated to works fabrication records, works test certificates, delivery notes and the like. Wherever possible, the marks shall be painted both on the inside and outside of pipes and fittings close to one end which, in the case of pipes and fittings with socket and spigot joints, shall be the socket end.

Marking shall be at least 50mm high.

Where there is insufficient smooth surface area to accommodate the above information the marking shall be put on rust proofed metal tags secured to the item with galvanised wire.

Spigots shall have marks to ensure the correct register of the spigot in the socket (for example two white painted lines).

4A.8.2.4 Thrust Flanges

Thrust flanges shall be integral with the pipe and shall be designed to act in either direction and to transfer into the concrete surrounding the pipe and flange the thrust imposed on a blank flange fixed to the end of the pipe by an internal hydrostatic pressure equal to the factory test pressure.

4A.8.2.5 Detachable Flexible Couplings and Flange Adapters

Detachable flexible couplings or flange adapters shall only be used where shown on the Drawings or with approval of the Engineer.

Detachable flexible couplings shall be suitable for the angular deflections specified below without leakage. Flange adapters shall be suitable for half the angular deflection stated.

Nominal pipe diameter (mm)	Angular deflection (degrees)
Up to 600	5
601 to 750	4
751 to 900	3
901 to 1200	3
1201 to 1800	2
1801 upwards	1

Flexible couplings for each size of pipe shall also be capable of withstanding the shear force applied by the weight of a 4m length of pipe of that diameter full of water suspended between two couplings.

Detachable flexible couplings shall be provided with central registers or location plugs only where specified or detailed in the Drawings.

Flange adapters shall have flanges as specified for flanged joints.

Bolts, nuts and washers shall comply with the requirements for bolts, nuts and washers for flanges.

The metal components of detachable flexible couplings and flange adapters shall be protected by thermoplastic polyamide or fusion-bonded epoxy coatings unless otherwise specified or detailed in the Drawings.

4A.8.3 HDPE PIPES (CABLE DUCTS)

Except where shown otherwise buried ducts shall be High Density Polyethylene (HDPE) pipes complying with ISO 8770/8772.

Joints shall be spigot-and-socket solvent cement-welded or rubber-ring type or other approved.

Draw cords shall be provided in all ducts. The draw cord shall be a polypropylene cord having a breaking load of not less than 5kN. Joints in the draw cord shall be kept to a minimum. They shall be at least as strong as the cord and shall be so made as not to cause any jamming in use.

4A.9 VALVES

4A.9.1 SCOPE

This Part covers the supply and testing of valves.

4A.9.2 REFERENCE STANDARDS

Valves shall be designed fabricated, tested and installed in accordance with the appropriate American, British or other Standard. Appropriate standards are listed below and are referred to within the particular clauses.

AWWA C502	Dry-barrel fire hydrants.
AWWA C504	Butterfly Valves
BS 1780	Bourdon tube pressure and vacuum gauges.
BS 1041	Temperature measurement.
BS 1042	Measurement of fluid flow in closed conduits.
BS 1400	Copper alloy ingots and copper alloy and high conductivity copper castings.
BS 1452	Flake graphite cast iron.
BS 2789	Spheroidal graphite or nodular graphite cast iron.
BS 2874	Copper and copper alloys rods and sections.
BS 3416	Bitumen-based coatings for cold application, suitable for use in contact with potable water.
BS 4147	Bitumen-based hot-applied coating materials for protecting iron and steel, including suitable primers where required.
BS 4504	Circular flanges for pipes, valves and fittings.
BS 4999	General requirements for rotating electrical machines.

BS 5156	Diaphragm valves
BS 5163	Predominantly key-operated cast iron gate valves for waterworks purposes.
BS 6755	Testing of valves
BS 970	Wrought steels for mechanical and allied engineering purposes: Part 1. General inspection and testing procedures and specific requirements for carbon, carbon manganese, alloy and valve steels.
BS EN 593	Industrial valves – Metallic butterfly valves.
EN 1092-2	Flanges an their joints – circular flanges for pipes, valve, fittings and accessories.
ISO 7005 –2	Metallic Flanges - Part 2

4A.9.3 MATERIALS, SUBSTANCES AND PRODUCTS

Valves shall be manufactured to the requirements specified hereunder. All valves shall be suitable for use with water at the temperatures and pressures specified or detailed on the Drawings.

Where the Contractor proposes to use dissimilar metals either in contact or close enough for the gap between them to be bridged by an electrolyte the Contractor's design shall include provisions to prevent corrosion.

Gate valves (sluice valves) and butterfly valves shall be suitable for flow in either direction.

Valves shall be suitable for frequent operation as well as for operation after long periods of idleness in any position.

Rubber used in valves shall be ethylene propylene rubber (EPDM or EPM) or styrene butadiene rubber (SBR). It shall comply with the requirements of Appendix B of BS 5155, be suitable for making a long-term flexible seal and be resistant to mechanical, chemical or bacteriological attack leading to deterioration of the flexible seal.

Valve components shall be of materials not inferior in strength or resistance to corrosion to those listed below.

Component	Material
Bodies, covers, cowls and plungers	Spheroidal graphite iron to BS 2789 grade 500/7 or 420/12
Pistons, sleeves, liners, guides, bushes, seats, seat rings and seal holders	Gunmetal to BS 1400 grade LG2
Hinge bushes and pins	Bronze to BS 2874 grade PB 102

Valve stems, spindles other than extension spindles and pins	Stainless steel to BS 970: Part 4, grade 431 S29 or grade 316S16 Aluminium Bronze to BS 2874 CA104
Extension spindles (plain ends)	Galvanised mild steel to BS 970: Part 1, grade 220 MO7

Except where otherwise specified all valves shall be suitable for continuous use in the range - 0ºC to +60ºC.

The pressure rating of all valves shall not be less than the maximum working and test pressure of the pipeline in which the valve is to be installed.

Valves shall be supplied with all necessary accessories such as hand wheel, extension shaft, couplings, caps, bolts, nuts, washers and 3mm cotton reinforced rubber gaskets for each flange.

Valves shall close clockwise.

All copper alloys which may come into contact with raw, treated or potable water shall contain not more than 4% zinc.

4A.9.3.1 Painting And Protection

Except where otherwise specified and except for stainless steel valve parts, all valves shall be fusion-bonded epoxy coated externally and internally to a thickness of at least 150 microns.

Fusion-bonded epoxy coatings shall be suitable for application to ductile iron based material used in contact with fresh water, brackish water or distillate in any soil conditions or in chamber applications. The coating shall consist of a polymeric anticorrosion barrier.

The coating system requirements, performance testing and factory applied coating requirements and practice shall be in accordance with the Water Industry Specification (WIS) 4-52-01.

The method of surface preparation and cleaning shall be in accordance with the Contractor’s specification which shall be no less than the minimum requirements specified by the coating material manufacturer and the following requirements:

a) The pre-coating surface shall be blast-cleaned to a minimum standard of Grade B Sa 2½ in accordance with BS 7079: Part A1;

b) The surface shall be tested for soluble salts and re-blasted if soluble salts are found to be present;

c) All oil, grease and other

d) All oil, grease and other contaminants shall be removed;

e) All slivers and scabs made visible by blast cleaning and detrimental to the coating process shall be removed;

f) Welds shall be fettled smooth;

g) Edges and corners shall be smoothed to a 3.0mm minimum radius;

h) Any pre-treatment prior to coating shall not be permitted without the written approval of the Engineer.

The shot-basted surface shall have a roughness RZ between 40μm and 80μm inclusive.

Raised flange faces shall be dressed after coating to remove coating runs.

Unless otherwise specified, each item shall be checked for holidays over all of the coated surfaces. A valve with two or more holidays per $3m^2$ of surface area shall be rejected for subsequent stripping and re-coating. All holidays detected shall be repaired and on completion the item shall be re-examined for holidays. After repair the coating shall be holiday free to Class A.

All coatings shall be treated with a UV-inhibitor to prevent chalking or loss of colour.

Materials and instructions shall be supplied for repair of coating damaged in transit and on site. Repair materials shall be compatible with the coating in colour and adhesion and shall be suitable for site application.

4A.9.3.2 Marking

Each body will be marked by Cast-on or stamped figures as follows:

- Size of Valve
- Year of Manufacturing
- Working Pressure
- Type of Casting

4A.9.3.3 Tests

Each valve shall be tested according to the standard specification and the Employer shall be supplied with the records of all tests.

4A.9.3.4 Flanges

Flanges shall be ductile iron NP10, NP16 or NP25 as defined in the Bill of Quantities and shall have the following metric dimensions:

NP10 Flanges

Nominal Diameter	Flange O.D. (mm)	Bolt Circle Dia. (mm)	Bolt Hole Dia. (mm)	Bolt Number	Bolt Dia.
200	340	295	23	8	M20
250	395	350	23	12	M20
300	445	400	23	12	M20
350	505	460	23	16	M20
400	565	515	28	16	M24
450	615	565	28	20	M24
500	670	620	28	20	M24
600	780	725	31	20	M27
700	895	840	31	24	M27
800	1015	950	34	24	M30
900	1115	1050	34	28	M30
1000	1230	1160	37	28	M33
1200	1455	1380	40	32	M36
1400	1675	1590	43	36	M39
1600	1915	1820	49	40	M45
1800	2115	2020	49	44	M45
2000	2325	2230	49	48	M45
2200					
2400					

The drilling of flanges for 2000 mm and 2200 mm dia. shall be done as per Engineer's approval.

NP16 Flanges

Nominal Diameter	Flange O.D. (mm)	Bolt Circle Dia. (mm)	Bolt Hole Dia. (mm)	Bolt Number	Bolt Dia.
200	340	295	23	12	M20
300	455	410	28	12	M24
600	840	770	37	20	M33
800	1025	950	40	24	M36
1000	1255	1170	43	28	M39
1200	1485	1390	49	32	M45

1600	1930	1820	56	40	M52
1800	2130	2020	56	44	M52
2000	2345	2230	62	48	M56
2200					
2400					

NP25 Flanges

Nominal Diameter	Flange O.D. (mm)	Bolt Circle Dia. (mm)	Bolt Hole Dia. (mm)	Bolt Number	Bolt Dia.
200	360	310	28	12	M24
300	485	430	31	16	M27
600	845	770	40	20	M36
800	1085	990	49	24	M45
1000	1320	1210	56	28	M52
1200	1530	1420	56	32	M52

4A.9.3.5 Bolts, Nuts and Washers

Bolts nuts and washers shall be galvanized to BS729.

Nuts and bolts shall be manufactured to BS 4190 ISO metric black hexagonal bolt screws and nuts. They shall be threaded in accordance with BS 3643 par 2 ISO metric series threads.

Each bolt shall be provided with a nut and two 3mm thick washers.

Each bolt shall be of sufficient length to show two threads past the nut when installed.

4A.9.3.6 Gaskets

Gaskets shall be suitable for use with both flanges with raised faces and between flanges with fully machined faces.

Gaskets shall have a minimum thickness of 3mm rubber incorporating two layers of cotton fabric. The gaskets shall be suitable for use at pipeline pressures up to 25 bars.

Gaskets shall comply with the relevant sections of BS 5292 and their dimensions shall be in compliance with BS 4865.

4A.9.4 OPERATING GEAR

Valves shall be clockwise closing and shall include on indicator to show the valve position.

Valves shall be capable of being opened and closed manually by one person, when the specified maximum unbalanced pressure is applied to the valve in use. The force

required to open the valve from the closed position should not exceed 125N at each of two diametrically opposite points on the rim of a 0.4m diameter hand wheel.

Operating gear shall be watertight under an external head of 10.0m of water.

4A.9.5 ISOLATION VALVES

4A.9.5.1 General

Isolation valves include:

- Butterfly valves (At inlet and outlet pipelines.)
- Sluice valves

4A.9.5.2 Operation

Isolation valves will be manually operated and installed in chambers.

Valves shall be clockwise closing and shall include an indicator to show the valve position.

Valves shall be capable of being opened and closed manually by one person, when the specified maximum unbalanced pressure is applied to the valve. The force required to open the valve from the closed position should not exceed 125N at each of two diametrically opposite points on the rim of a 0.4m diameter hand wheel.

Operating gear shall be watertight under an external head of 10.0m of water

4A.9.5.3 Extension Spindles

Line valves and washout valves shall be installed with extension spindles, spindle caps, spindle supports, protection tubes and surface boxes to permit operation of the valve from outside of the chamber.

The Contractor shall design, supply and install suitable extension spindles for all line and washout valve installations including for those valves supplied by the Employer. Spindles including fixing, mountings and couplings shall be designed for the maximum operating torque with a factor of safety of two.

Spindles shall be circular in section and provided with suitable bearings rigidly held on brackets spaced no more than 1500mm apart.

Couplings shall be robust and provided with adequate pinning to carry the shear and prevent pullout.

One T key shall be supplied for every five valves installed, with a minimum requirement of two keys in any one size.

4A.9.5.4 Gate Valves (Sluice Valves)

Gate valves up to and including 600mm nominal diameter shall conform to the requirements of BS 5163 for copper alloy faced with a solid wedge.

The valves components shall be manufactured from the following materials:

Body, bonnet, stuffing box, cap	Ductile Cast Iron to BS 2789 Grade 420/12 or Grade 500/7
Stem	Aluminium bronze to B.S.2874 CA 104
Wedge	Ductile Cast Iron to BS 2789 Grade 420/12 or Grade 500/7
Facing rings	Gunmetal to B.S.1400 LG2
Hand wheel (where required)	Cast Iron to B.S.1452, Grade 17 min.

Valve spindles shall be of the internal non-rising type. The valve spindle seal shall be replaceable with the valve fully open and the main under pressure.

The valve stem shall be made in one piece and shall be able to withstand without permanent distortion all stresses, compressive, tensile and torsional, to which it could be subjected. The stem diameters above and below the collar shall comply with the dimensions given in table (4) of BS5163/86 (Type B, for A1 Bronze to B.S.2S74 CA 104 material).

Except where otherwise shown gearbox spindles for hand wheel/tee key or for connecting with an extension spindle shall be vertical when the valve is installed. Gate valve shall be manually operated and shall be closed clockwise.

Valves shall not contain any brasses that have more than 5% zinc.

The length over flanges for Gate Valves (Sluice Valves) shall be as specified below:

Size (mm.)	Face to Face Dimension (mm.)
200	400
300	500

4A.9.5.5 Butterfly Valves

Butterfly valves shall comply with BS EN 593 or AWWA C504, except as specified herein. Valves shall be suitable for mounting in any position and shall be designed to be used as a regulating valve and closing valve.

Valves shall be mounted with shafts horizontal unless otherwise specified or shown on the Drawings. Valves over 350 mm bore shall be provided with bevel gearing.

Valves shall be fitted with indicators to show the position of the disc.

The Contractor shall provide details of the materials of manufacture and of the valve design, including the access route to repair or replace seals and shall provide evidence to show that the proposed materials and seating designs for the sealing and seating arrangements have given satisfactory performance in similar conditions to those applying under the Contract.

Flanges and hubs for shaft bearing housings shall be integrally cast with the valve body. All bearings shall be maintenance-free of a self-lubricating or sealed-for-life type.

Disc edges shall be machined with rounded corners and shall be polished to a smooth finish. The valve disc shall rotate through an angle of 90 degrees from the fully opened to the fully closed position and the seat shall be designed so as to close at an angle normal to the axis of the pipe. Hollow discs and any other castings with voids shall be fitted with watertight threaded plugs.

Discs shall be capable of maintaining their fully open and fully closed positions with the gearbox removed. Limit stops shall be capable of absorbing full operating torque with a minimum design safety factor of 5.

Shafts shall be fabricated of stainless steel grade 316 S16 to BS 970 part 4. Body-seats shall be fabricated of stainless steel grade 316 S16 to BS 970 part 4 or made of back-up welded nickel face (nickel weld overlay).

The shaft and disc fixing shall be capable of absorbing the full operating torque with a minimum design safety factor of 5 and will safely sustained maximum differential pressure across the closed valve. Shaft seals, when used, shall be of the resilient O-ring type. Packing shall be either of the resilient 0-ring or of the self-adjusting chevron type.

The sealing ring shall be replaceable without the need to remove the valve body from the pipework in which it is fitted.

The valve body and disk shall be of ductile cast iron of quality not less than BS 2789 grade 500/7. In general the materials chosen shall be corrosion resistant to the source water referred to in the Specification. All bolts, nuts and other fixings, which will be in contact with the flow or with the ground shall be of stainless steel type 316-S16.

Bolts retaining the removable seal cover and the body seat ring shall be of stainless steel type 316-S16 to BS 970 Part 4.

Valves shall be suitable for submergence below water.

The valves shall be capable of being seated and unseated under the most adverse conditions appropriate to its rating.

The gearbox spindle for hand wheel/tee key or for connecting with the extension spindle shall be vertical when the valve is installed.

Valves greater than 600mm diameter shall be provided with suitable support feet.

Butterfly valves shall be resiliently seated.

The face-to-face dimensions of butterfly valves shall be as detailed below: -

Size (mm.)	Face to Face Dimension (mm)
2000	950
1800	870
1600	790
1200	630
1000	550
800	470
600	390

Each valve shall be tested in accordance with the requirements of BS EN593, for body test, seat test and disc strength test. Seat tests shall be carried out in each direction and the valve shall be drop tight. Disc strength tests shall also be carried out in each direction.

4A.9.5.6 Resilient-seated Butterfly Valves

Service application for resilient-seated valves shall be “tight shut-off”. The valve seal shall be EDPM, EPM or SBR, durable and replaceable. The rubber sealing ring shall be made of nitrile synthetic rubber (or equal) suitable for permanent contact with Fresh or Brackish water at a permanent temperature of at least 50°C.

The valve seal shall be securely clamped to the edge of the disc by seal-retention members or other equivalent retention device in such a manner as to prevent leakage of water under the seal and to hold the seal securely in position during opening and closing of the valve disc. The seal-retention members shall be of stainless steel and shall be securely fastened to the body or disc with stainless steel fasteners. Stainless steel shall be Grade 316-S16.

The seal and its retention members shall be adjustable to ensure water tightness and to minimise the seating and unseating friction forces. When all the seal retention members are in place the finished edges of the seal shall fit closely and the surface shall be smooth with all fastenings set flush in the water passage so as to offer the least resistance possible to the flow of water through the valve.

Valve seats which extend over the face of the flanges to secure the seat in place, or which require surface grinding and/or hand fitting of the disc, or designs which require the adjoining pipe flange to retain the seat in place and resist line pressure, are not acceptable.

4A.9.6 AIR VALVES

4A.9.6.1 General

Air relief valves shall be double air valves designed to meet the following conditions:

(a) Discharge air during charging of the pipework;

(b) Admit air during emptying of the pipework.

(c) Discharge air accumulated at local peaks along pipelines under normal operating conditions.

Conditions (a) and (b) shall be met by the employment of a large orifice capable of handling large volumes of air at a high flow rate, and condition (c) by a small orifice capable of discharging small quantities of air as they accumulate.

4A.9.6.2 Small-orifice

The small-orifice for relief of air under pressure and/or in bulk shall automatically open and exhaust accumulated air from a pipeline and shall automatically close when all air has been exhausted from the pipeline. The valve shall function properly at all pressures up to maximum working pressure.

Each valve shall be fitted with a test cock in the valve body to permit easy verification that the valve is operating properly and that its orifice is not blocked.

Valves shall be capable of discharging not less than $0.5m^3$/min of free air when the pressure in the pipeline is at the maximum working pressure for which the valve is designed.

4A.9.6.3 Large-orifice

The large-orifice shall automatically open to allow air into a pipeline as it is drained of water or ventilate air out from a pipeline as it is filled with water. The large-orifice shall close automatically when all air has been exhausted from the pipeline on filling. Valve shall be constructed so that the air flow actively holds the valve open during air flows in both directions up to the design discharge.

The large orifice shall, when coupled to its respective isolating valves, be capable of admitting air to and exhausting air from the pipeline at $200m^3$/min without the pressure differential across the combined air valve and isolating valve exceeding 0.25 bar.

4A.9.6.4 Materials

The valve components shall be manufactured from the following materials:

Body, Bonnet, Cover	Ductile Iron to BS.2789, Gr.420/12 or Gr.500/7.
Float	Vulcanised rubber or stainless steel Gr.316-S16 to BS 970/4 or high impact polypropylene.
Float Guide	Gunmetal to BS 1400 LG2
Cock	Gunmetal to BS 1400 LG2

Valves shall have approved screening arrangements, made of stainless steel, to prevent the ingress of foreign matter.

Floats shall be in one part without any welding or Fusion processes. Floats with centre guide shall not be accepted. Floats and seats shall be designed so as to minimise the risk of adhesion of the ball to the seat. They shall be of a type proved by experience to be suitable for the specified duties. Floats of air valves shall seat against its orifice or cause the orifice to close without leakage of water at all pressures measured at the valve between 0.1 bar and the maximum working pressure. Orifices shall be nylon, bronze or stainless steel.

The valve body shall be fitted with Gunmetal guides (to BS.1400-LG2) for the Floating balls.

Vulcanised rubber and any other rubber parts shall be suitable for use with Distillate or Brackish water and withstand to a temperature not less than 50°C.

All air release openings shall be directed downwards.

4A.9.6.5 Non-slam Air Valves

Non-slam air valves shall be double air valves as specified above except that the air valve shall be fitted with a vented non-return valve or other device which permits air to enter the pipeline freely on low pressures caused by surges within the pipeline, but which controls the expulsion of any air drawn into the pipeline under surge conditions in order to minimise 'slam' as the air is finally expelled from the pipe.

The non-slam air release & vacuum break valve shall be of the compact single chamber design with solid cylindrical H.D.P.E. control floats housed in a tubular stainless steel body with epoxy powder coated cast iron or steel ends secured by means of stainless steel tie rods. The valve shall have an integral 'Anti-Shock' Orifice mechanism which shall operate automatically to limit transient pressure rise or shock induced by closure to 2 x valve rated working pressure.

The intake orifice area shall be equal to the nominal size of the valve. Large orifice sealing shall be effected by the flat face of the control float seating against a nitrile rubber 'O' ring housed in a dovetail groove circumferentially surrounding the orifice. Discharge of pressurised air shall be controlled by the seating and unseating of a small orifice nozzle on a natural rubber seal fixed into the control float.

The valve construction shall be such that leaking or damage of any kind does not occur by submission to twice the designed working pressure. Valves shall not exhibit leaks or weeping of liquid past the large orifice seal at operating pressures of 0.5 bar to twice rated working pressure.

The valve design shall incorporate an over pressure safety feature that will fail without an explosive effect, such as is normally the case when highly compressed air is released suddenly. The feature shall consist of easily replaceable components such as gaskets, seals or the like.

The valve shall be designed such that prior to the ingress of liquid into the valve chamber, as when the pipeline is being filled, valves shall vent through the large orifice when water approach velocities are relative to a transient pressure rise, on valve closure, of < 2 x valve rated pressure. At higher water approach velocities, which have a

potential to induce transient pressure rises > 2 x valve rated pressure on valve closure, the valve shall automatically discharge air through the Anti Shock Orifice and reduce water approach velocity, so that on closure a maximum transient pressure rise of < 2 x valve rated pressure is realised.

Valves shall respond to the presence of air by discharging it through the small orifice at any pressures within a specified design range, i.e. 0.5 bar to 16 bar, 25 bar or 40 bar dependent upon the location of the valve. The valve shall remain leak tight in the absence of air.

Valves shall react immediately to pipeline drainage or water column separation by the full opening of the large orifice so as to allow unobstructed air intake at the lowest possible negative internal pipeline pressure.

4A.9.7 CHECK VALVES (NON-RETURN VALVES, REFLUX VALVES)

4A.9.7.1 General

Check valves may be of single/multiple door or tilting disc type, suitable for installation in the required position. Other types of valves may be acceptable, subject to the approval of the Engineer,

Check valves shall be designed for rapid closing without slamming no later than the moment of cessation of forward flow.

4A.9.7.2 Single-door Swing Check Valves

Single-door swing check valves hall have a single port sealed by means of a gate with hinges offset outside the area of the port. The gate shall open automatically on start of flow in one direction and close automatically on flow reversal. Closure of the gate may be assisted by weights or weighted levers.

Unless otherwise specified, valves shall conform to BS 5153 and shall be double-flanged.

4A.9.7.3 Multiple-door Swing Check Valves

Multiple-door check valves are swing check valves except the valves shall have two or more parallel ports each with separate hinged gates.

Unless otherwise specified, valves shall conform to the general requirements for swing type valves as specified in BS 5153.

4A.9.8 BALL VALVES

4A.9.8.1 General

The ball valves shall be subjected to frequent opening and closing. Therefore these values should be of sturdy construction, heavy duty durable, little maintenance and provide trouble-free operation.

The valves shall comply as far as possible with B.S.S. 5351 or equivalent and the specifications detailed after have to be followed.

The ball valves shall be full bore type and with flanged ends.

Unless otherwise specified, the flanges shall be drilled according to B.S. 10, Table E.

The valve body shall be in one piece.

A complete set of bolts, nuts, washers and one gasket of 3mm thick cotton reinforced shall be supplied for each flanges.

4A.9.8.2 Class

The valves, unless otherwise specified shall be designed for a working pressure of 10 Kg/cm^2, and for a service water temperature ranging between 0°C in winter and 50°C in summer.

4A.9.8.3 Materials

The valve components shall be manufactured from the following materials:

Body, body connector, ball stem, gland, gland nut, body connector bolting, are required to be of austenitic stainless steel to B.S. 970, part I grade 316 s11 (18/10/2LC) or grade 316 S31 (18/10/2).

Body seat ring are required to be made from PTFE resins without fillers and from virgin material completely free of reclaimed processed material.

Stem seals, body seals and gaskets material shall be suitable for use at the maximum temperature rating applying to the valve, and the minimum corrosion resistance of any metallic part of gasket shall be equal to the corrosion resistance of the shell.

4A.9.8.4 Testing

Each valve shall be pressure tested hydrostatically to the standard specification. The shell test pressure shall be 1.5 x PN i.e. 15 bar & the seat pressure shall be 1.1 x PN i.e. 11 bar and the engineer shall be supplied with the records of all tests.

4A.9.8.5 Dimensions

The face to face dimensions unless otherwise specified shall be as detailed in B.S. 2080

4A.9.8.6 Operation

The valves shall be manually operated, supplied with wrenches unless otherwise specified and the operating handle (wrench) shall be not less than 11 inch in length and the wrench shall be of ductile iron.

4A.9.8.7 Marking

Each valve shall be marked with the cast or stamped lettering giving the following information:

- Nominal Size DN
- Nominal Pressure PN

- Body Material Designation
- Manufacturer's Name or Trade Mark
- Arrow to Indicate Direction of Flow

4A.9.8.8 Technical Data

Catalogues, Leaflets and comprehensive technical information should be submitted. The tenderer should also submit with his offer detailed working drawings for the offered valves showing all parts, dimensions and material specifications.

4A.9.8.9 Accessories

Each valve shall be supplied with all accessories such as :

- Bolts, nuts, washers and 3mm cotton reinforced rubber gaskets for each flanges
- Ductile Iron hand wheel and ductile iron wrench of 11 inch in length.

4A.10 COATINGS AND PROTECTION

4A.10.1 SCOPE

This part covers the coating and protection systems to pipes, fittings and valves.

4A.10.2 PROTECTION OF DUCTILE IRON PIPES & DUCTILE IRON FITTINGS

4A.10.2.1 External Protection of Ductile Iron Pipes and Fittings

Ductile iron Pipes and fittings shall be factory coated externally with a layer of metallic zinc of minimum thickness 20 microns. Application methods shall be in accordance with BS EN 545 or ISO 8179. Pipes and fittings shall be further protected externally with an approved bitumen-based coating pigmented with aluminium of thickness not less than 100 microns.

The external surfaces of spigot ends up to 250mm from the end shall be coated with an approved 2-pack solvent free epoxy resin of thickness not less than 100 microns, applied in accordance with the manufacturers instructions.

No pipes with significant damage to the external coating will be accepted. Where, in the opinion of the Engineer damage to the coating is minor, it shall be repaired as far as possible in accordance with the original coating system, subject to the approval of the Engineer.

4A.10.2.2 Internal Protection of Ductile Iron Pipes and Fittings

Pipes and fittings shall be lined in accordance with AWWA C104/A21.4-95 with cement mortar lining (double thickness) and a seal coat. The lining thickness shall be to Section

4.7.2 as specified below and the seal coat shall comply with Section 4.11. Cement shall be ASTN C150 Type II Portland cement.

Pipe diameters (mm)	Lining thickness (mm)
60 to 300	3.2
350 to 600	4.8
700 and greater	6.4

Tolerance on linings shall be as specified in AWWA C104 Table 8. Cement mortar linings shall be machine-applied. There shall be no cracks in the cement mortar lining.

Subject to the approval of the Engineer fittings may be coated wholly internally and externally with epoxy paint of thickness not less than 150 microns and suitable for drinking water at temperatures up to 50°C. No pipes with significant damage to the internal coatings will be accepted. Where in the opinion of the Engineer damage to the coatings is minor it shall be repaired as far as possible in accordance with the original coating system. The repair shall be subject to the approval of the Engineer.

4A.10.2.3 Spigots and Sockets

The internal surfaces of sockets (and external surfaces of spigot ends up to 250mm from the end) shall be coated with an approved 2-pack solvent free epoxy resin of thickness not less than 100 microns, applied in accordance with the manufacturers instructions.

4A.10.2.4 Protective Wrapping Tape Systems

The protective wrapping tape for the external protection of pipes and fittings shall comprise a thick plastic tape coated on one side with a heavy self-adhesive bituminous or butyl rubber compound.

The adhesive compound shall form at least 50 % of the total tape thickness.

The product shall achieve the following minimum performance values when tested as per methods indicated below.

	Performance Value	Test Method
Total tape thickness Compound thickness PVC thickness	1.6 mm 0.85 mm 0.75 mm	-
Tensile Strength	12 N/mm	ASTM D1000
Elongation of non- strengthened tape	250%	ASTM D638
Tear Resistance	45 Newtons	ASTM D1004

Impact Resistance (double layer)	15 (Joules)	ASTM G13
Adhesion	2.00 N/mm	ASTM D1000
Dielectric strength	20 Kv	-
Insulation resistance	1,000,000 Mega ohms/Sq. cm	-
Operational temperature range	-20 to + 80 deg. C	-
Water vapour permeability	0.6 g/Sq.m/24hrs	ASTM E96
Water absorption	0.25% at 23 deg. C/ 24 hrs	ASTM D570
Holiday test voltage	10/15/ kV	-

Note: Elongation for tapes strengthened with approved inert fibres may be reduced to 25%. However all tapes must be sufficiently deformable to ensure close wrapping of all joints and fittings.

4A.10.2.5 Outer wrap Protective Tape

The outer wrap to the bituminous protective wrapping tape shall comprise a PVC carrier coated with a pressure sensitive adhesive Wrapping Tape. The product shall achieve the following minimum systems performance values: -

	Performance Value	**Test Method**
Total tape thickness	0.2 mm	-
Tensile strength	2.6N/mm	ASTM D1000
Elongation	180%	ASTM D638
Tear Resistance	8 Newton	ASTM D1004
Dielectric Strength	10KV	-
Operational temperature range	0 to 75 ºC.	

All tapes must be sufficiently deformable to ensure close wrapping of all joints and fittings.

4A.10.2.6 Primer

The wrapping system for pipes shall, unless otherwise approved by the Engineer, include a bituminous based quick drying surface primer which shall be compatible with the wrapping tape and external pipe coating. The primer shall be as recommended by the

tape manufacturer and be fast drying and suitable for cold application by brushing and spraying and be compatible with the factory applied pipe coating.

4A.10.2.7 Polyethylene Sleeving

Buried ductile iron pipes, fittings and joints shall be double sleeved with site applied polyethylene sleeving. Factory applied sleeving shall not be used.

Polyethylene shall be in accordance with BS 6076 or 'C' of AWWA C.105, except as otherwise specified.

Suitable adhesive PVC tape shall be used to fix the sleeving in position and to make joints between adjacent sections.

Sleeving shall be black Class C.

4A.10.2.8 Heat-shrink Sleeving

Heat-shrink sleeves for use at pipe joints to complete fusion-bonded epoxy coatings shall be manufactured from heavy-duty radiation cross-linked polyolefin sheet material, coated on one side with high shear strength hot-melt adhesive.

4A.10.2.9 Fusion-bonded Epoxy Coating

Fusion-bonded epoxy coatings shall consist of a polymeric anti-corrosion barrier applied at a factory approved by the Engineer.

The coating system requirements, performance testing and factory applied coating requirements and practice shall be in accordance with the Water Industry Specification (WIS) 4-52-01.

The method of surface preparation and cleaning shall be in accordance with the Contractor’s specification which shall be no less than the minimum requirements specified by the coating material manufacturer and the following requirements:

- The pre-coating surface shall be blast-cleaned to a minimum standard of Grade B Sa 2½ in accordance with BS 7079: Part A1;
- The surface shall be tested for soluble salts and re-blasted if soluble salts are found to be present;
- All oil, grease and other contaminants shall be removed;
- All slivers and scabs made visible by blast cleaning and detrimental to the coating process shall be removed;
- Welds shall be fettled smooth;
- Edges and corners shall be smoothed to a 3.0mm minimum radius;
- Any pre-treatment prior to coating shall not be permitted without the written approval of the Engineer

- The shot-blasted surface shall have a roughness RZ between 40µm and 80µm inclusive.

The minimum and maximum thickness of coatings for pipes and fittings shall be as in the table below: -

Location	Minimum	Maximum
Pipe walls	300 microns	1.6mm
Fittings including flanges	300 microns	2.0mm
Inside bolt holes	300 microns	2.0mm

All thickness-critical surfaces shall be coated to the thickness specified and within the tolerances identified. Raised flange faces shall be dressed after coating to remove coating runs.

Unless otherwise specified, each item shall be checked for holidays over all of the coated surfaces. A fitting with two or more holidays per $3m^2$ of surface area or a pipe with thirty or more holidays per pipe length shall be rejected for subsequent stripping and recoating. All holidays detected shall be repaired and on completion the item shall be re-examined for holidays. After repair the coating shall be holiday free to Class A.

All coatings on pipes and fittings shall be treated with a UV-inhibitor to prevent chalking or loss of colour.

External protection to pipes to be surrounded in concrete over part of their length shall extend at least 150mm within the concrete.

4A.10.2.10 Repairs

Materials and instructions shall be supplied for repair of coatings damaged in transit and on site. Repair materials shall be compatible with the coating in colour and adhesion and shall be suitable for site application.

In the event of a fusion-bonded epoxy coating being damaged after leaving the factory the item shall be returned to the factory for repair or, with the consent of the Engineer, be repaired at Site. Site repairs will not be permitted where the total area of damage to be repaired on a single pipe or fitting exceeds $6cm^2$ for pipes and fittings up to and including 600mm diameter and $12cm^2$ for pipes and fittings in excess of 600mm diameter. Repairs shall be effected in accordance with the manufacturer's recommendations. Notwithstanding such recommendations the repair shall meet the following minimum requirements:

- Repair materials shall be compatible with the original factory-applied coating materials and, where applicable, they shall comply with Clause 4A.10.2.9;
- The edges of the original factory-applied coating shall be ground off to a taper or feather edge;
- Exposed metal shall be cleaned and prepared as specified in Clause 4A.10.2.9;

- The relative humidity of the atmosphere in which the repair is to be effected shall be maintained (if necessary by the use of hot-air blowers and tenting) at less than 85%, a wet/dry thermometer being provided during repairs to demonstrate humidity;
- The surface temperature of the exposed metal shall be raised to at least 3^{o}C above dew point and the coating shall then be applied in stages, as recommended by the manufacturer, so as to achieve a total thickness in accordance with Clause 4A.10..2.9;
- All repairs shall be checked with a holiday detector and any holidays shall be repaired, after which the repairs shall rechecked.

4A.10.2.11 Two-part Epoxy Coating

Two-part epoxy coating shall be applied in accordance with the manufacturer's recommendations and shall meet the minimum requirements as follows:

Surface preparation of exposed metal shall be as specified for fusion-bonded epoxy coating.

The coating shall be applied in two or more layers to a minimum thickness of 300 microns.

The relative humidity shall be maintained at less than 85% during application of coating material. The surface temperature of the metal during application shall be raised to at least 3°C above dew point.

All surfaces shall be checked with a holiday detector following application. All holidays found shall be repaired.

Adequate ventilation shall be provided during application and curing of the materia

4A.11 JOINTS AND ANCILLARIES

4A.11.1 SCOPE

This part covers joints to pipes, fittings and valves.

4A.11.2 SPIGOT AND SOCKET JOINTS

4A.11.2.1 General

Push-in socket and spigot joints shall permit pipes to be deflected angularly by up to 2° axially for diameters up to 900mm and by up to 1.5^{o} axially for diameters over 900mm.

4A.11.2.2 Joint Sealing Rings

Joint sealing rings shall be obtained from the manufacturer of the pipe or joint.

Joint sealing rings shall comply with the relevant requirements of BS EN 681 or AWWA C111/21.11, shall be rubber, suitable for making a long-term flexible seal between the pipes and shall be suitable for the ambient and climatic conditions in Kuwait, for water temperature of 50°C and be resistant to mechanical, chemical or

bacteriological attack leading to deterioration of the flexible seal. Rubber for sealing rings shall be ethylene propylene rubber (EPDM or EPM), acrylonitrile butadiene rubber (nitrile) or styrene butadiene rubber (SBR) which complies with the above requirements.

Lubricants used during jointing shall have no deleterious effects on either the sealing ring, pipes or pipe coating and shall be unaffected by the liquid to be conveyed.

4A.11.2.3 Mechanical (Bolted Gland) Joints

Where detailed on the drawings spigot and socket joints to fittings shall be the mechanical (bolted gland) type supplied with rubber gasket and bolts. Glands should be ductile iron of the same quality as the fitting and shall be supplied with a bituminous coating of thickness not less then 100 microns. On a fixed spot on the outside of each gland the manufacturers name or identification mark, date of manufacture and nominal diameter shall be marked. Bolts for use with bolted gland joints shall be spheroidal graphite in accordance with BS 2789 Grade 500/7.

4A.11.3 FLANGES AND FLANGED JOINTS

4A.11.3.1 General

Flanges shall be compatible with the flanges on materials supplied by the Employer.

Back faces of flanges shall be machined.

The Contractor shall ensure that flanges are compatible in all cases, including where connections are to be made to existing pipe flanges.

Where flanges are coated with paint, fusion bonded epoxy or other materials, the coated surfaces of mating faces shall, whilst maintaining minimum coating thickness, be prepared as necessary to ensure suitable regular surfaces for mating. Bolt holes shall be reamed out as necessary to allow insertion of bolts whilst maintaining minimum coating thickness.

4A.11.3.2 Flange Dimensions

Flanges shall be ductile iron NP10, NP16 or NP25 to ISO 2531 and drilled to

ISO 7005-2 as follows:

NP10 Flanges

Nominal Diameter	Flange O.D. (mm)	Bolt Circle Dia. (mm)	Bolt Hole Dia. (mm)	Bolt Number	Bolt Dia.
200	340	295	23	8	M20
250	395	350	23	12	M20
300	445	400	23	12	M20
350	505	460	23	16	M20
400	565	515	28	16	M24

450	615	565	28	20	M24
500	670	620	28	20	M24
600	780	725	31	20	M27
700	895	840	31	24	M27
800	1015	950	34	24	M30
900	1115	1050	34	28	M30
1000	1230	1160	37	28	M33
1200	1455	1380	40	32	M36
1400	1675	1590	43	36	M39
1600	1915	1820	49	40	M45
1800	2115	2020	49	44	M45
2000	2325	2230	49	48	M45
2200					
2400					

NP16 Flanges

Nominal Diameter	Flange O.D. (mm)	Bolt Circle Dia. (mm)	Bolt Hole Dia. (mm)	Bolt Number	Bolt Dia.
200	340	295	23	12	M20
300	455	410	28	12	M24
800	1025	950	40	24	M36
1200	1485	1390	49	32	M45
1600	1930	1820	56	40	M52
1800	2130	2020	56	44	M52
2000	2345	2230	62	48	M56
2200					
2400					

Dimensions NP25 Flanges

Nominal Diameter	Flange O.D. (mm)	Bolt Circle Dia. (mm)	Bolt Hole Dia. (mm)	Bolt Number	Bolt Dia.
200	360	310	28	12	M24
300	485	430	31	16	M27
800	1085	990	49	24	M45
1200	1530	1420	56	32	M52

4A.11.3.3 Bolts, Nuts and Washers

Bolts nuts and washers shall be galvanized to BS729.

Nuts and bolts shall be manufactured to BS 4190 ISO (ISO 4014) metric black hexagonal bolt screws and nuts. They shall be threaded in accordance with BS 3643 part 2 ISO metric series threads. Each bolt shall be provided with a nut and two 3mm thick washers. Each bolt shall be of sufficient length to show two threads past the nut when installed.

4A.11.3.4 Gaskets

Gaskets shall be suitable for use with both flanges with raised faces and between flanges with fully machined faces. Gaskets shall be inside bolt circle type to BS EN 1514-1 of materials complying with BS EN 681. Gaskets shall comply with the relevant sections of BS 5292 and their dimensions shall be in compliance with BS 4865. Gaskets shall have a minimum thickness of 3mm rubber incorporating two layers of cotton fabric.

Gaskets shall be one piece EPDM rubber of hardness 80, of minimum thickness 3mm and of such physical properties as to be capable of forming permanent watertight joints against pressures up to the maximum test pressure. The use of jointing paste, adhesive tape or grease on gaskets will not be permitted.

4A.11.4 ANCHORED JOINTS

Self-anchored couplings and flange adapters shall not be used for transmission of axial loads.

4A.11.5 CONNECTIONS BETWEEN DIFFERENT PIPE CLASSES

Where different types or classes of pipe material are jointed together, the Contractor shall supply special fittings or stepped couplings designed and manufactured to suit the ends of pipes to be jointed. Stepped couplings shall comply with the requirements for detachable flexible couplings and flange adapters where applicable.

4A.12 CONSTRUCTION OF PIPELINES

4A.12.1 SCOPE

This part covers the installation of buried pipelines.

4A.12.2 SETTING OUT

Pipelines shall be accurately installed to even grades and to the lines and levels shown on the Drawings so that the barrel of the pipe is continuously supported throughout its length by the bedding material. The line and level of the pipeline shall be as shown on the Drawings or as directed by the Engineer.

The Contractor shall submit details of the methods he proposes to use for control of the accuracy of pipe laying. The position of any pipe shall be within ±25 mm of the specified level and within ±100mm of the horizontal alignment.

Strong sight rails marked the centre line and the level to which the pipeline is to be laid shall be fixed and maintained at each change of gradient and at as many intermediate points. Alternatively the Contractor may use laser techniques.

4A.12.3 PIPELINES IN THE SAME TRENCH

The minimum clear spacing between barrels of adjacent parallel pipes shall be 600mm. Unless otherwise shown the crown levels of the pipelines shall be at the same level.

4A.12.4 BURIED PIPES GENERAL

Trench excavation and backfill shall be co-ordinated with the construction of the pipeline as a whole so as to ensure expeditious completion of the whole operation.

Flexibly-jointed socket and spigot pipes shall normally be laid with sockets leading. Where the gradient exceeds 5%, installation shall proceed on an ascending grade with sockets leading. Pipes shall be installed singly and shall not be jointed until after they have been laid. After laying and jointing, the level of each pipe shall be checked before the next pipe is laid.

Pipe bores shall be kept clean and free from water, dirt, stones and other foreign matter.

When installation is not proceeding a suitable stopper shall be installed to seal the open ends of pipes.

The Contractor shall take such precautions as are necessary to prevent pipes from floating.

4A.12.4.1 Concrete Bed and Surround

Where shown on the Drawings or directed by the Engineer concrete bedding haunches and surround shall be provided in accordance with the typical details shown on the Drawings. Concrete shall be un-reinforced of the class shown on the Drawings. Any formwork required shall be Class F1.

Each pipe shall be supported on at least two purpose-made pre-cast concrete blocks, which shall be left in place. In-situ concrete shall be placed after the joints at each end of the pipe have been completed and the pipeline has been checked and adjusted for alignment. The concrete shall be placed and carefully worked and compacted beneath and around the pipe. Unformed surfaces shall be of spade finish. The pipe shall be prevented from floating or otherwise moving during concreting.

The continuity of concrete bed, haunch or surround to pipes with flexible socket and spigot joints shall be broken at each flexible joint by 25mm thick fibreboard, placed against the face of the socket. The concrete bed, haunch or surround shall be discontinued at detachable flexible couplings, leaving a clearance of 75mm each side of the coupling.

Where two or more pipelines are laid in the same trench, the joints shall coincide at the joints in the largest diameter pipeline where the continuity of the concrete bed, haunch

or surround shall be broken. Any intermediate joints in the smaller diameter pipelines shall be surrounded in concrete.

4A.12.5 JOINTING

Before making any joint the Contractor shall ensure that the interior of each pipe or fitting is clean and shall prepare the ends for jointing as necessary. All mechanical joints shall have their coating made good before assembly in accordance with the coating manufacturer's recommendations.

Only the proper jointing parts as specified and obtained from the suppliers of pipes or fittings shall be used.

Joints shall be made in accordance with the manufacturer's instructions.

Unless otherwise specified or detailed in the Drawings the deflection of a flexible joint shall not exceed 50% of the maximum value specified by the manufacturer.

Bolts for flanged and other mechanical joints shall show two threads clear of the nut after tightening.

Stainless steel nuts and bolts shall be lubricated before assembly with an anti-galling lubricant. Nuts shall be tightened to the torques recommended by the joint manufacturer. Torques shall not exceed values at which there is risk of galling.

After completing the joint any protective or other coating shall be made good and the joint protection and sleeving completed without delay.

4A.12.7.1 Flanged Joints

Joint rings for flanged joints may be fastened to the bolts with cotton thread. The use of jointing paste, adhesive tape or grease will not be permitted.

The bores of abutting pipes or fittings and the joint gasket shall be concentric; no joint material shall be left protruding into the bore. Nuts shall first be tightened by hand and nuts on opposite sides of the joint circumference shall then be alternately and progressively tightened with a spanner so as to ensure even pressure all round the joint.

4A.12.6 WORK INSIDE PIPELINES

The Contractor shall maintain adequate safety and monitoring systems, access, lighting and ventilation to any part of a pipeline where work is undertaken inside the pipes.

4A.12.7 CUTTING OF PIPES

Pipes shall not be cut until after adjacent pipes have been laid and jointed and accurate measurement of the length and the required angle and shape of the cut can be made.

The cut shall be neatly performed by an experienced skilled man using tools or machinery appropriate for the type and diameter of pipe to be cut. The cut ends of the

pipes shall be shaped up and trimmed so as to ensure an accurate joint. Any damage to wrapping, coating or lining shall be made good.

The unused part of any cut pipe shall be disposed of off the Site unless, with the Engineer's approval, it can be used elsewhere in the Works or it is required to be returned to the Employer.

4A.12.9.1 Closing Lengths

Pipes for closing lengths or for inserting into pipelines already laid shall be cut to allow a gap of at least 20mm between adjacent pipe ends. Otherwise, the gap shall be as recommended by the manufacturer of the coupling. The closing joints in pressure pipelines shall be made with bolted gland collars unless otherwise shown on the Drawings.

4A.12.8 EXTERNAL PROTECTION

4A.12.10.1 Sleeving of Pipelines

Double layer polyethylene sleeving shall be installed so that it is continuous over joints and fittings in accordance with the following procedure:

Immediately before lowering the pipes into the trench they shall be cleaned of all soil and foreign matter and any damage made good.

The sleeve shall be slipped over the pipes and secured in place using adhesive PVC tape. The sleeving shall be pulled tight against the bottom invert of the pipe and the excess girth shall be gathered at the top of the pipe and folded. The sleeve at the ends of the pipes shall be left loose until after jointing and any wrapping of the joint. The loose sleeving shall then be carefully pulled over the joints so that it is continuous. The overlaps shall be secured with PVC tape at not more than 600mm centres. Bends, tees and similar fittings shall be protected similarly.

Any sharp edges such as at bolted gland or flanged joints shall be padded with four thicknesses of sleeving material before the sleeve is pulled over them.

Care shall be exercised during handling, installing and backfilling to prevent damage to the sleeving. Any minor damage to the sleeving shall be repaired by wrapping a sheet of material cut from the sleeving material right round the pipe and so that it provides an overlap of at least 200mm past each side of the puncture; all edges being taped to the sleeving.

Sleeving shall be omitted from the sections of pipes and fittings which are embedded in concrete chambers. Before placing the concrete, the end of the sleeving shall be folded back clear of the concreting operations and a run of adhesive PVC tape not less than 50mm wide shall be affixed around the pipe barrel so that the centre of the tape is aligned with the eventual position of the concrete face. After concreting is completed, the sleeving shall be pulled over the pipe up to the concrete face and secured to the pipe barrel with PVC tape such that the end of the sleeving overlaps the tape previously placed around the pipe and so that no part of the pipe remains exposed. The termination

of the sleeving shall be completed by placing a further run of adhesive PVC tape around the pipe, spanning between the end of the sleeving and the face of the concrete.

Sleeving shall be continuous around fittings (bends and tees) at thrust blocks.

4A.12.10.2 Tape Wrapping with Outer wrap for Ductile Iron Pipelines

Pipes shall be wrapped at locations shown on the Drawings or as directed by the Engineer. Buried wrapped pipes shall be additionally protected by polyethylene sleeving.

The Contractor shall submit details of the proposed methods of cleaning, priming, application of mastic putty, tape wrapping and the equipment to be used for wrapping to the Engineer for approval before commencing work.

Primer, mastic putty and wrapping tapes shall be obtained from the same manufacturer and be compatible.

Prior to wrapping all surfaces shall be cleaned and primed.

Pipes of 400mm diameter and above shall be machine wrapped. The wrapping tape shall be applied in a spiral manner under tension to ensure conformability and adhesion to the barrel of the pipe or fitting. The wrapping shall have a minimum 55 per cent overlap and shall be wrinkle and bubble free. A length of 200mm at the spigot shall be left unwrapped until after jointing.

When a new roll of tape is started, the end lap shall be overlapped on the roll a minimum of 150mm, measured circumferentially and shall be smooth and placed so as to maintain the continuity of the wrapping.

The Contractor shall prove the wrapping to be holiday free using a holiday detection meter and voltages to the approval of the Engineer.

On completion of wrapping with protective tape an outer wrap shall be applied over the protective tape using the same type of mechanical equipment as used to apply the protective tape. The overlap of the outer wrap shall not coincide with the overlap of the protective tape. The outer wrap may be applied at the same time as the protective tape and shall have a minimum 50mm overlap.

The minimum end lap of two rolls shall be 150mm measured circumferentially. The outer wrap shall be applied such as to initially leave 300mm at the spigot unwrapped.

After the wrapped pipes are laid and jointed a mastic putty shall be applied at the joint to smooth out the external pipeline profile The putty shall be applied as a fillet with an angle to the pipe axis not exceeding thirty degrees.

Tape wrapping and outer wrap shall then be made continuous over the joint by hand wrapping.

The Contractor shall prove the joint wrapping and exposed pipe wrapping to be holiday free using a holiday detection meter and voltages to the approval of the Engineer.

4A.12.10.3 External Wrapping of Fusion-bonded Epoxy Coated Pipes and Fittings

Field joints of fusion-bonded epoxy coated pipes shall be protected by heat-shrink sleeves. The sleeve shall be pre-cut to size and wrapped around the pipe or fittings before it has cured. The completed sleeve shall conform to the pipeline shape, show no blisters or sign of air entrainment and the hot-melt adhesive shall be visible as a flow from all edges.

4A.12.10.4 Protection of Buried Bolted Couplings, Adapters and Flanges

After jointing and testing, corrosion protection shall be applied to all buried detachable couplings, adapters, flange adapters, mechanical (bolted gland) joints and flanged joints. All such joints shall be thoroughly cleaned and wrapped with tropical grade petroleum jelly impregnated open weave cotton, synthetic fibre or glass fibre tape. The tape shall be suitable for use in the prevailing climatic and soil conditions and be applied in accordance with the manufacturer's instructions. Profiling putty shall be used as required to provide a regular surface for wrapping. The tape shall extend at least 200mm over the adjacent pipe barrel.

All bolts shall be rechecked for tightness before wrapping tape is applied.

4A.12.9 CONNECTING TO EXISTING PIPELINES

Before starting any connection into an existing pipeline the Contractor shall verify the exact dimensions and the materials necessary. The Contractor shall excavate trial pits, prepare designs, and obtain the Engineer's approval and liase with the authority responsible for the operation of that pipeline.

The Contractor shall prepare a detailed method statement for the completion of the connection, clearly indicating the period for which it will be necessary for the existing pipeline to be taken out of service The period of planned shut-down shall be kept to the minimum practicable in the circumstances.

The statement shall also detail the methods and plant to be employed, standby plant to be made available and the measures that will be taken to prevent contamination of the existing pipeline.

The statement shall be subject to the approval of the Engineer and of the operating authority.

Unless otherwise agreed in writing the operation of valves necessary to isolate the section of the existing pipeline and subsequently to restore it to service shall only be undertaken by staff of the operating authority. If so instructed by the Engineer the Contractor shall assist the authority in carrying out any activities necessary to facilitate the efficient completion of work on the connection.

The new pipeline and, where practicable, the existing pipeline at the connection shall be tested for leakage. Any existing pipe, fitting or joint leaking due to damage occurring during the connection operation shall be removed and replaced by the Contractor at no extra cost to the Employer.

4A.12.10 PLUGGING OF DEAD ENDS

The buried dead ends of existing pipes broken out shall be plugged with concrete. The buried ends of new pipes or fittings installed at this time for future connection at Stage 2 shall be sealed with a timber stopper wrapped with petroleum jelly impregnated tape and outer wrapped with polyethylene and adhesive tape.

4A.12.11 MARKER POSTS AND INDICATOR PLATES

Marker posts shall be installed only after the Engineer has approved their location.

Posts and indicator plates shall be as shown on the Drawings. The marker posts shall be set up as soon as practicable after trench excavations have been backfilled.

4A.12.12 MARKER TAPE

Marker tape shall be 50mm wide and 0.1mm nominal thickness coloured polythene or similar approved system boldly printed with the word “CAUTION” and words to identify the particular service throughout its entire length, in accordance with the following coding:

Types of Service	Tape Colour	Service Identification Wording
Water Supply Line	Blue	WATER MAIN BELOW
Instrumentation, Telephone & Telemetry Cables	Red	CONTROL CABLE BELOW

4A.13 CHAMBERS AND THRUST BLOCKS

4A.13.1 SCOPE

This part covers the installation of valves and fittings and the construction of chambers and thrust blocks.

4A.13.2 ANCHOR AND THRUST BLOCKS

Unless otherwise detailed in the Drawings thrust blocks shall be constructed with the bottom, thrust and side surfaces bearing against undisturbed ground.

If blinding concrete is required or allowed to be placed beneath any horizontal thrust block shear keys shall be formed on its upper surface.

The surfaces of concrete thrust blocks not cast against undisturbed ground shall be waterproofed with two coats of bituminous paint.

Where steel beams for resisting the thrust of pipelines are installed under this Contract for future pipelines they shall be protected with a wrapping of petroleum jelly impregnated tape and outer wrapped with polyethelene sheet and adhesive tape.

4A.13.3 VALVE AND OTHER CHAMBERS

The thrust-bearing surfaces of pipeline chambers which are designed to carry thrusts shall be constructed against undisturbed ground as shown on the Drawings.

If undisturbed ground has not been maintained the gap shall be backfilled with C35/40 mass concrete.

Pipes shall project from the external faces of the chambers by the amounts stated for ductile iron pipes in Clause 4A.13.6 unless otherwise shown on the Drawings or instructed by the Engineer.

Top surfaces of walls supporting pre-cast concrete cover slabs shall be to true line and level. Lifting holes or eyes in pre-cast components are to be provided as shown on the Drawings or as directed by the Engineer.

The outer surfaces of concrete chambers shall be waterproofed as detailed on the drawings and Specified in Specification Clause 4A.6.15.

Where pipes are built into chambers for connection in the future the buried exposed end shall be plugged with a timber stopper and wrapped with petroleum jelly impregnated tape and outer wrapped with polyethylene sheet and adhesive tape.

4A.13.4 INSTALLATION OF VALVES

Valves shall be installed and commissioned in accordance with the manufacturer's instructions. After installation valves shall be cleaned. Gates, discs, seats and other moving parts shall be closely inspected and all foreign matter removed and the valve shall be checked for ease of operation. Moving parts shall be lightly greased or otherwise treated as the manufacturer instructs to bring them into a good operating condition. Valves within chambers or other structures shall be protected from damage and dirt with suitable approved covering until commissioning.

Butterfly valves shall be fixed with the disc spindle horizontal and installed so that when the valve is opening the lower portion of the disc moves in the direction of the main or normal flow.

Except where shown otherwise in the Drawings gate valves shall be fixed with their spindles vertical.

4A.13.5 DRAW PITS

The Contractor shall submit details for the draw pits for cable ducts which shall be either precast or insitu concrete class C35A. The roof slab shall be precast concrete with lifting hooks to enable it to be removed.

The cover shall be bedded and sealed as for the pipeline chambers.

The external faces of buried walls shall be painted with 2 coats of bitumen paint.

Where ducts are built into the walls the openings shall be sealed and made good.

4A.13.6 PIPELINES BUILT INTO STRUCTURES

4A.13.6.1 Excess Excavation

Any excavation beneath the formation line of a pipe trench adjacent to a structure shall be backfilled to the formation line with concrete Class 20/40. The concrete shall extend at least 500mm beyond the extremities of the pipe on each side.

4A.13.6.2 Thrust Flanges

Pipes passing through the walls of chambers shall be provided with thrust flanges where shown on the Drawings.

4A.13.6.3 Pipeline Spacing at Structures

Where it is necessary to increase the spacing of pipelines at structures such as chambers and thrust blocks the deviation shall be made by deflecting the pipe joints. Deflections shall be limited to 50% of the maximum allowable stated by the manufacturer.

4A.13.6.4 Pipework in Chambers

Pipework systems shall be complete and checked for correct position and alignment before being concreting in.

The Contractor shall ensure that no excessive loads or stresses are imposed upon the pipework or structure and shall adequately support the pipework during installation until permanent supports and anchorages are completed

Where pipe fittings are cast into in-situ concrete walls and where a puddle flange is not required to resist forces rubber sealing rings shall be installed.

4A.13.6.6 Painting of Pipes, Fittings and Valves

Factory-applied coatings on pipes, fittings and valves in chambers and other exposed areas shall be made good on completion of construction of the chambers as necessary to return the items to the appearance on leaving the factory.

Where specified exposed pipes, fittings and valves and their joints shall be over-painted to a colour to be agreed with the Engineer. Paint systems for over-painting shall be compatible with any factory coatings including coatings made good on site.

Bitumen coated items shall be primed with two coats of aluminium sealer to a total dry-film thickness not less than 30 microns. Top coats of approved colour of alkyd chlorinated rubber finish shall be applied sufficient to give a total over-paint dry-film thickness of 80 microns.

Where shown on the drawings or specified FBE or epoxy-coated items shall be lightly rubbed down with emery to provide a key and painted with two coats of alkyd or epoxy finish coats of approved colour.

---- END OF SECTION ----

MINISTRY OF ELECTRICITY AND WATER

WATER PROJECTS SECTOR

CONSTRUCTION AND MAINTENANCE OF 5 NOS. R.C. GROUND RESERVOIRS FOR FRESH WATER, 55 M.I.G CAPACITY EACH, AND ANNEXED WORKS AT MUTLA HIGH (STAGE-II)

SECTION 4A.14

SPECIFICATIONS OF CONCRETE

REFER SECTION 4B

(SPECIFICATIONS OF RESERVOIRS FOR CONCRETE WORKS)

MINISTRY OF ELECTRICITY AND WATER

WATER PROJECTS SECTOR

CONSTRUCTION AND MAINTENANCE OF 5 NOS. R.C. GROUND RESERVOIRS FOR FRESH WATER, 55 M.I.G CAPACITY EACH, AND ANNEXED WORKS AT MUTLA HIGH (STAGE-II)

SECTION - 4B

TECHNICAL SPECIFICATION FOR R.C. RESERVOIR WORKS

TABLE OF CONTENTS

4B.1 GENERAL:

4B.1.1 Introduction

These specifications relate to the civil engineering works involved in the construction of reinforced concrete ground reservoirs with certain ancillary works as shown on drawings and described in specifications, including all internal and external pipe works up to the limits shown on drawings, also includes all required connections to the existing pipelines if any.

4B.1.2 Drawings

These specifications are accompanied by the drawings listed in Appendix 1 hereto, and to be read in conjunction therewith.

4B.1.3 Standards

All material used and provided under this contract shall be in accordance with the latest edition of the standards stated. Where no standards exists, as for example in the case of patents or special materials, all such materials and workmanship shall be of the best quality, and full details of materials and any tests to which they are subjected, shall be submitted with the Tender for approval.

4B.1.4 Leveling Datum

All levels and drawings and other documents relating to this contract are shown in metres. Benchmarks for leveling will be indicated to the Contractor by the Engineer.

4B.1.5 Climate

4B.1.5.1 Temperature

Ambient Air Temperature:

Maximum air temperature	-	49 °c.
Average Maximum, July	-	44 °c.
Mean July, August	-	37 °c.
Mean June	-	36 °c.
Average Minimum July	-	29 °c.
Average Minimum August	-	28 °c.
Minimum January	-	-4 °c.

Sun radiation temperature on " Black bulb " Thermometer:

Maximum June, July, August	-	84 °c.
Maximum January	-	57 °c.
Average Maximum June, July, August	-	74 °c.
Average Maximum January	-	48 °c.

Ground Temperature 1.2m. Below Ground Level in Gatch:

Maximum August - 36 °c.
Mean August - 35 °c.
Minimum January, February - 18 °c.

4B.1.5.2 Relative Humidity

Absolute maximum - 98%
Average Maximum January - 85%
Average Maximum December - 81%
Average Maximum June - 40%
Mean January, December - 68%
Average Min. Jan., Dec. - 45%

4B.1.5.3 Sunshine

Average December - 6.9 hour per day.
Average August - 10.7 hour per day.

4B.1.5.4 Evaporation

Observations made with a Class 'A' Pan in the Open.

December - 2.7 mm/day
June - 18.3 mm/day
July - 17.9 mm/day

4B.1.5.5 Visibility

Number of days with visibility less than 3 km due to rising sand.

Year	J	F	M	A	M	J	J	A	S	O	N	D
1960	2	2	4	5	8	6	5	2	1	0	2	1
1961	2	3	6	2	9	10	14	2	6	2	2	0
1962	1	5	2	5	4	4	3	1	2	0	4	1

4B.1.5.6 Rainfall

Season	Kuwait	Ahmadi
1960-1961	120mm	105mm
1961-1962	105mm	75mm
1962-1963	95mm	--

The distribution of the rainfall over the area varies considerably. A great deal of the season rainfalls usually occurs over a few days with a tendency towards concentration in November - December. Rainfall of up to 15 mm in minutes has been recorded.

4B.1.5.7 Winds

The annual percentage frequency of wind speed is listed below:

Mean wind speed m/s	Frequency all direction %
13-18	20
19-24	7
25 and more	2.5

Maximum dust recorded is 37.6 m/s

4B.1.6 Limit of Site

The Contractor will be required to confine his activities to the limit of the Site as indicated on the drawings or delineated by the Engineer and he shall take special care to avoid any damage to trees, flowers and orchards outside these areas by his traffic plant or workmen, due allowance being made for access and the provisions of the conditions of contract should the Contractor require for any purpose additional land outside the above stated area he shall arrange for it at his own expense and shall on request provide the Engineer with copies of permission from the owners or occupiers for use of such land. The Contractor will be responsible for rent or any other charges in respect of such additional land.

The Contractor shall also be responsible for any damage to trees, flowers and orchards or other damage or injury incident to or which may be occasioned by the use of such additional land or any land outside the aforementioned limit of the site and he shall make all payments in compensation consequent there to notwithstanding however compliance with the requirements of the conditions of contract.

4B.2 WORKS COMPRISING:

4B.2.1 Scope of Contract

See particular specifications and conditions.

4B.2.2 Operations Involved

See particular specifications and conditions**.**

4B.3 GENERAL REQUIREMENTS:

4B.3.1 Works to be Furnished by the Contractor

All materials and works of whatsoever description required for any structures or work of a permanent or temporary nature in connection with this contract shall be provided by the Contractor.

4B.3.2 Sanitary Arrangements

Immediately upon entry on any site under the contract, the Contractor shall provide adequate sanitary conveniences for all persons properly engaged upon the works in accordance with the requirements of

the local authorities and the instructions of the Engineer. Such accommodation shall be maintained as and where necessary throughout the duration of the construction period and for as long thereafter as may be deemed necessary by the Engineer and the Contractor shall keep the same in a clean and orderly condition at all times and when directed clear away the conveniences and thoroughly disinfect the Sites as necessary entirely at his own expense.

4B.3.3 Water Supplies

The Contractor shall be responsible for and shall make his own arrangements for the supplies of water including water for testing, water tightness of the reservoirs and he shall pay all connection and other charges therefore and any rates due to the supplying authority.

All water delivered to the site shall be clean, fresh, and free from oil, acids, alkalis, organic matter and other deleterious substances. In general, fresh or brackish water will be acceptable for use by most trades other than concerning provided it is clean and contains not more than 4,000 ppm of dissolved solids of which no more than 1000 ppm may be chlorides. For concreting work the water must comply with the requirements stated in clause 4B.7.5 of this Specification.

The Contractor shall similarly be responsible for and pay all charges in connection with a supplier of drinking water which shall be provided to all sites.

4B.3.4 Power Supplies

The Contractor shall be responsible for and shall make his own arrangements, with regards to the supplies of Electricity to the Site including any necessary supply lines or in certain cases the Contractor's own generating equipment. He shall pay all costs and other charges therefore and shall pay for supplies obtained from the local authorities at the rates laid down by the supplying authority.

4B.3.5 Sign Boards

The Contractor shall provide sign boards written in Arabic and English as prescribed by the Ministry at each Site of work and office, or such other places as directed by the Engineer, and remove the same on completion of the contract. The sign boards shall show the followings:

- Name of Ministry.
- Name of Contractor.
- Nature of Works.
- Date of Commencement.
- Date of completion.

The minimum size of all sign boards shall be 1.5 x 2.0 m. with the bottom of the sign set 1.40 m. above ground level. The color scheme shall be red lettering in a white background.

4B.3.6 Site Laboratories

The Contractor shall at his own expense provide, erect and maintain a field laboratory as required by clause 4B.7.12.1 of this Specification. The laboratory shall be of adequate size and shall be

supplied with running water and electricity and the Contractor shall equip the laboratories with the apparatus called for in the above mentioned clause.

The Contractor should note that no work which is in any way dependent on tests or testing to be carried out at these site laboratories may be commenced until such time as the laboratories are fully equipped in accordance with the above named requirements and all the instruments and equipment are in full operational order and to the satisfaction of the Engineer. The Contractor shall be solely responsible for any delays to or stoppages of the work caused by missing of non-approved, faulty, otherwise unsatisfactory equipment or break down, insufficient capacity or any other cause whatever at these site laboratories. On completion of the contract, the Contractor shall remove the laboratories and make good the sites.

4B.3.7 Setting of Temporary Buildings, etc.

The Contractor shall agree with the Engineer as to the setting of all temporary buildings, sheds, latrines, huts and stores and all sites for mixing plants, aggregate, stockpiles and bulk cement hoppers as well as stacking areas for large consignments of pipes, bricks or other bulky materials before he commences to erect such buildings or plant or stack such equipment or materials. On completion, the Contractor shall be responsible for the complete removal of all such temporary buildings or structures and materials or equipment and shall make good the sites and surrounding areas to the satisfaction of the Engineer.

4B.3.8 Cleanliness of Site

Throughout the period of construction, the Contractor shall keep the site and all temporary and permanent works in as clean and tidy state as may reasonably be expected and he shall at all times maintain the whole of the works in a safe and clean condition.

4B.3.9 Commencement of Works

The Contractor shall commence the works on site within the period stated in the tender after the receipt by him of an order in writing to this effect from the Engineer and shall proceed with the same with due expedition and without delay except as may be expressly sanctioned or ordered by the Engineer or by wholly beyond the Contractor's control.

4B.3.10 Record Drawings

The Contractor shall be responsible for the preparation of Record Drawings of the works as executed or constructed which shall show clearly all deviations from the original drawings. Within two months of the completion of any main portion of the works, the Contractor shall supply to the Engineer the originals and two copies of each complete set of such drawings of the works as executed. Proper cover for each set of drawings sheet should be 594 x 841mm.

These drawings shall be fully detailed and shall be drawn to the same scales as the corresponding contract drawings and shall be printed on linen or stout paper. Drawing's shall be submitted before acceptance and taking over. Full particulars of the drawings to be furnished on the reversed face of the card including the reduction ratio.

In addition to the above mentioned requirements, the Contractor should supply and deliver to the Engineer one set digitized copy for all the Record drawing of the project after MEW approval. (For more details, see Section of Particular Conditions).

4B.3.11 Obstructions

The Contractor shall not obstruct unduly, the traffic whether vehicular or pedestrian in any public or private road, footway or place and shall at once remove any obstruction, whether plant, vehicle or material, which the Engineer may not consider to be necessary for the execution of the works.

The Contractor shall have open at one time only such excavation or lengths of trench as the Engineer shall deem necessary for the good and continued progress of the work and shall not cause obstruction by having an undue quantity of equipment pipes, fittings, excavated building or other materials stacked in public places but shall at his own cost arrange suitable storage and stockpiles for such equipment or materials not immediately required for use.

4B.3.12 Temporary Traffic Signs

The Contractor shall erect and maintain on the works and at prescribed points on the approaches to the works, all traffic signs necessary for the direction and control of traffic and the size of all such signs and the lettering and wording there on shall be in accordance with the Kuwait Traffic Code and approved by the Engineer before erection. The signs shall be reflectorized or adequately illuminated by night by approved means.

4B.3.13 Control of Traffic

In the event of single way traffic becoming necessary on any particular section of the works to which the public have vehicular access or on the approaches to the works the Contractor shall in maintaining through traffic routes provide a width of at least 3m for single way traffic. He shall also provide approved electrically operated signals for traffic control on each of the affected sections and any additional traffic signs as may be required. The electric signal lights are to be hand operated by a competent operator provided by the Contractor if and when required by the Engineer. Manually operated "stop – go" signs will only be permitted if approved by the Engineer and shall be of the color size and type required by the traffic code.

4B.3.14 Temporary Diversion of Traffic

Wherever the site intersects existing public or private roads footpaths, tracks or any other temporary or permanent access such that access is no longer possible, temporary diversion ways shall be constructed. Such diversion ways shall be of such a standard of construction that they are suitable in all respects for the class or classes of traffic requiring using them and shall be adequately maintained throughout their period of use and cleared away on completion.

4B.3.15 Temporary Access

In addition to the requirements of the conditions of contract, the Contractor shall provide maintain and remove on completion of the works all temporary works including roadways, sleeper, tracks

and staging etc. Over roads, footpaths, streams or unstable ground to provide access for any persons or vehicle entitled to such access. Such temporary works shall be kept safe at all times and shall be suitable in every respect for their purpose and maintained to the satisfaction of the Engineer.

4B.3.16 Late Submission for Testing

It shall be the Contractor's responsibility to ascertain which materials and articles are required to be tested and to present such materials and articles or samples or specimens thereof for testing. Should there be doubt as to whether any material or article is required for testing the Contractor shall seek clarification from the Engineer and the Contractor will be entitled to no claim whatsoever for delay or any other cause arising from the rejection of materials or articles which the Contractor omitted to submit for testing.

It shall further be the Contractor's responsibility to prepare samples and specifications and submit them for testing well in advance of the time the materials or articles will be required for use. It is emphasized to the Contractor that the Research Station has a great amount of work on hand and it may take a considerable time for the testing of all the materials, and to allow for the possibility of samples failing the tests and new samples beings obtained and tested it is essential that the Contractor submits samples and specimens sufficiently.

The Contractor shall not be entitled to any compensation nor shall any claim be accepted by the Employer in respect of delay, inconvenience, damage, standing time or any other cause whatsoever arising from or consequent on late submission of materials or articles for testing.

4B.3.17 Materials Arising from Excavation and Demolition, etc.

The Contractor may not sell or otherwise dispose of any materials arising from the excavations demolitions and the like carried out on site unless expressly permitted by the contract documents or the Engineer. In every case possible and whenever instructed the Contractor shall use such material in the work as directed by the Engineer.

4B.4 INSPECTION:

4B.4.1 Shop Inspection

All materials furnished by the Contractor or his Sub-contractor, shall be subject at the discretion of the Engineer, to inspection and approval at the plant of the Manufacturer. The Employer will pay the cost of his own representative’s attendance at such inspections.

4B.4.2 Inspection of Adjacent Structures

Before the commencement of work on the site and if necessary the Contractor shall arrange a meeting with the Engineer so that any buildings, plant, roads or other structures in such close proximity to any proposed trenches or excavations that they may suffer damage by the work may be inspected by the Contractor & Engineer together. The Contractor shall then at his own expense

draw up a report which shall describe accurately the conditions of the buildings, plant, roads or other structures which may be affected, particular attention being paid to the size and situation of any existing cracks, and shall be accompanied by an adequate number of photographs and any other information of helpful nature. This report is to be agreed and signed by the Engineer before excavation or vibration work is commenced in the neighborhood of such structures.

4B.4.3 Inspection of Site Works

Before the commencement of work on the site, the Contractor shall arrange a meeting with the Engineer to examine all those parts of the Site that are to be restored to their original state when work is completed. Such parts shall be inspected by the Contractor & Engineer together and the Contractor shall be responsible for drawing up an inspection report including all necessary details, photographs, measurements and other helpful, data. This inspection report shall be agreed and signed by the Engineer before any work is commenced and at the completion of the work the Contractor will be responsible for leaving the various parts of the site in comparable state to that indicated in the inspection report. All expenses in drawing up such report and the subsequent finishing and clearing up the work to the various parts of the site shall be borne by the Contractor.

4B.4.4 Facilities for Engineer's Inspection

The Contractor shall provide all necessary equipment, tackles access, labour and instrument to enable the Engineer or his representative to carry out conveniently such inspections as he may deem necessary at all times during the currency of the Contractor.

4B.4.5 Inspection During Maintenance Period

The Engineer shall give the Contractor due notice of his intention to carry out inspections during the period of maintenance & the Contractor shall thereupon arrange for all necessary equipment, labour etc., & for a responsible representative to be present at the times & dates named by the Engineer.

4B.5 PROTECTIVE MEASURES AND PRELIMINARY WORK:

4B.5.1 Responsibility for Material Furnished by the Contractor

The Contractor shall be responsible for all material furnished by him or his Sub-contractors, and shall replace at his own expense all such material found defective or damaged. This shall include the furnishing of all material and labour required for the replacement of installed material discovered to be defective prior to the final acceptance of the Work.

4B.5.2 Responsibility for Safe Storage

The Contractor shall be responsible for the safe storage, handling and transportation to the places of use of all materials furnished by or to him under the Contract. The interior of all pipes, fittings and other accessories shall be kept free from dirt and foreign matter at all times and if necessary must be covered and protected. Protective coatings to pipes and similar materials or equipment must not be damaged in loading or handling operations and such precautions as required by the Engineer shall be taken to ensure their safety.

The Contractor is not allowed without the permission of the Engineer, to transport any material or equipment from the Site for use outside this contract.

4B.5.3 Specialist Contractors Storage

The Contractor shall either provide sufficient and adequate lock-up storage at the site for the use of the Specialist Contractors nominated by the employer for the installation of specialized equipment for the safe storage of their tools, equipment and materials or arrange for each such specialist to provide his own storage facilities. In either case the Contractor shall be responsible for the safety of all equipment etc., supplied by the specialist Contractor during storage. It shall he deemed that the Contractor has allowed in his prices for the necessary storage requirements for each such contract.

4B.5.4 Rejection of Defective Materials

Any material or item of equipment forming a part of the works which is found during the progress of the work to have cracks, flaws or any other defect shall be rejected forthwith by the Engineer. The Contractor shall be responsible for the removal of such defective material or equipment from the site without delay and the prompt replacement thereof with acceptable material or equipment. The employer will accept no claims of any description whatsoever rising from the rejection of such defective material or equipment or the replacement thereof.

4B.5.5 Protection of Water Sources

The various water sources shall be carefully protected against pollution of any kind. The location and layout of stores and depots for oil, petrol and similar fuels and the setting of maintenance garages and workshops shall be to the approval of the Engineer and shall not be permitted near the water sources. In the vicinity of water sources, filling of fuel for motors and similar operations shall be carried out carefully and all necessary precautions taken to ensure that no spillage or wastage can infiltrate the ground and pollute the water sources. Accidents, if any, shall immediately be reported to the Engineer.

4B.5.6 Protection of Existing Services and Foundations

Before the commencement of any excavation, the Contractor shall obtain detailed information from the appropriate authorities or owner of the location of pipelines, cables or any other underground services or foundations to buildings retaining walls etc., in the vicinity of the work irrespective of whether such services or foundations are indicated on the contract drawings or not. When any such underground service or overhead cables or wires or any other existing service apparatus of any description or building foundation or footing may be affected by the Work, the Contractor shall notify the owner of such service or foundation and the Engineer before work is commenced and the Contractor shall take all necessary precautions and carry out all such protection works as may be necessary or as the Engineer may direct. No work may be commenced until such precautionary measures have been carried out to the complete satisfaction of the Engineer and it is stressed that the protection of all existing services and foundations shall be the full responsibility of the Contractor, and the Contractor alone shall be responsible for any damage of whatsoever nature that may occur to any existing service or foundation and for all claims arising there from. It is further stressed that drawings supplied by owners of services are often diagrammatic or approximate only

and it shall be the Contractor's responsibility to determine by means of trial holes or other suitable methods the precise locations of all services and foundations of footings and no claims will be accepted by the Ministry or the Owners arising from inaccurate information shown on such drawings or omissions there from.

Excavation by machine shall in no case be carried out within two meters of cables, pipelines or any other services or service apparatus or foundations to buildings or structures and generally in the vicinity of any service or service apparatus. Building excavation by machine may only be carried out with the permission of the Engineer, and at all times the Contractor shall proceed with extreme caution when working close to existing services or foundations.

When it is necessary for existing services in or in the Vicinity of the excavations to be maintained, the Contractor shall ensure that such cables, ducts or pipelines are adequately braced, propped, supported or slung along the whole of their affected lengths. The supports shall be maintained throughout the whole period of exposure of the service and it shall be Contractor's responsibility to ensure that on and after back-filling or building in the said service is adequately supported with concrete blocks of other satisfactory means so that no damage will be caused to it on or after such backfilling or building protective covering to such cables or pipes shall not be damaged and all precautions shall be to the approval and satisfaction of the Engineer who may at any time either during the work or at any subsequent time order the Contractor to replace or pay the cost of replacing any sections of cable pipeline or other service that the Engineer has cause to believe has become damaged by the operations of the Contractor.

Any foundations to existing buildings in or alongside the excavations shall be supported by suitable braces, props or other means throughout the Contractor's operations and before backfilling shall be so permanently braced that they will not be affected by the settlement of the backfill. All such precautions shall be to the Engineer's approval and the Contractor shall be held responsible at any time for damage that appears in the structure as a result of the Contractor's operations.

4B.5.7 Diversion of Services

When the Documents call for the diversion of existing services, the Contractor shall give adequate notice to the Authorities owing such services before beginning diversion work and the Contractor shall plan and carry out all diversion work in consultation with each Authority Concerned. The Authority may wish to carry out the work themselves in which case the work shall be done at expense of the Contractor. All such diversions shall be completed to the satisfaction of the Engineer and the diverted services put into operation before the existing services are disconnected.

4B.5.8 Deviations Occasioned by Obstructions

Wherever obstructions not shown on the plans are encountered during the progress of the work and interfere to such an extent that an alternation in plan is required, the Engineer shall have the right to change the plans and order a deviation from the original design or a relocation of the obstruction and in such a case the Contractor shall not receive any compensation nor shall any claim be accepted for delay or any other cause whatsoever arising from or occasioned by such obstruction or any relocation thereof or any consequent deviation from the original design**.**

Should the Engineer order a deviation from the original design, the Contractor shall immediately comply with the altered design and should the Engineer order a relocation or diversion of the obstruction, it shall be the Contractor's responsibility to contact the owner of such obstruction and make all necessary arrangements for the relocation or diversion thereof in accordance with Clause 4B.5.7 above.

All deviation or relocation work shall be carried out by the Contractor to the complete satisfaction of the Engineer. If the change in plans results in a change in the amount of work by the Contractor, such altered work shall be done on the basis of payment to the Contractor for extra work or credit to the Employer for less work.

4B.5.9 Repair of Pipes, Fences, etc.

Pipes that have been moved, replaced or repaired in conjunction with the work may not be covered up until they have been inspected, and if necessary tested by the Engineer.

Walls and fences broken down or damaged during the work must, if so required by the Engineer be repaired immediately by the Contractor, or if not so required after the work on that section is finished.

Culverts and ditches temporarily altered to divert water during the progress of the Work must be relocated in their original positions unless the Engineer instructs otherwise.

4B.5.10 Safeguard of Survey Markers

Marking points, triangulation points, benchmarks and other surveyor's boundary marks of various kinds may not be removed from their positions not shall work be carried on so near to them that risk of disturbance may arise without permission from the Engineer. Instructions given by the land surveyor must be obeyed unconditionally and the replacing of disturbed or temporarily removed marks etc., must be supervised by the Surveyor.

If the Engineer considers that any such marking points provided at the expense of the Employer have been disturbed or lost due to neglect or carelessness of the Contractor then the Contractor shall be responsible for the costs of replacing such markers.

4B.5.11 Non-Obstruction to Public Utilities

The Contractor shall ensure the public utility equipment in or near the Site is kept accessible and free from obstruction at all times. Existing hydrants, water connections, valves pit covers, valve boxes, fire and police call boxes, etc., shall not be obstructed by materials or equipment and adequate free access to such equipment maintained. Street gutters and gullies shall be kept free from obstruction and dirt, or else other steps for street drainage taken during the works and the gutters or gullies cleaned out on completion.

4B.5.12 Interference with Public Utility Equipment

The Contractor is not permitted to make any connections temporary or otherwise, to not use any supplies from the public water, electricity, gas, telephone or other utility equipment. The Contractor shall also be responsible for ensuring that the equipment of such utilities, including valves, switches, taps, blow-offs and other controls in or near the site is not operated by his staff or personnel.

4B.5.13 Fencing of Site

As soon as the Contractor is placed in possession of any part of the site, he shall in places where permanent fencing cannot be erected immediately or where none is required, erect and when and where required re-erect and maintain temporary fencing wherever indicated by the Engineer.

In general, such temporary fencing will be required completely around all works carried out in public places or highways or anywhere else where persons or animals have access and will be required for the whole period of construction work, at that place. At the main delineated sites, temporary or permanent fencing will generally be required right around the whole site and shall be sufficiently robust and well erected to prevent any person or animals from entering except at the specific access points, which shall be provided with lockable gates. Temporary fencing may also be required to subdivide sections of the site within the boundary fence.

The cost of supply, erection and maintenance of such temporary fencing and all patrolling that may be necessary for the safety of the works and the materials stored on site will be deemed to be covered by the prices stated in the bill of quantities.

When an access is provided for owners, tenants or occupiers of adjoining lands it shall be maintained in a reasonable condition so that use of the access is at no time impaired by the operations of the Contractor.

Temporary fencing shall not be removed until it is replaced immediately by permanent fencing. If no permanent fencing is required the temporary fencing shall remain in position until completion of the whole of the works unless the Engineer agrees to its removal at an earlier date. When the fencing has been removed the ground shall be reinstated and left in a safe condition.

4B.5.14 Warning Signs

In addition to the requirements of Clause 4B.5.13 above, the Contractor shall at his own expense comply with the "Safety Regulations for properties and public Utilities" issued by the Ministry and shall take all precautions as mentioned therein for the safety and convenience of the public and others. Traffic signs barricades and wailing lights shall be erected illuminated and maintained in accordance with the above Regulations and the Contractor shall also comply with any further safety precautions considered necessary by the Engineer. It shall be deemed that the Contractor has allowed in his prices for all costs and expenses incurred in the provision and maintenance of all warning signs and other safety precautions.

4B.5.15 Setting Out of Reference Points

The Engineer will set out and establish by means of suitable pegs or other accepted markers adequate reference points with regard to line and level at each site to enable the Contractor to set out the Works. It shall be the Contractor's responsibility to obtain from the Engineer written details and values of such reference points and the Contractor shall take steps to safeguard such reference markers, as allowed for the Clause 4B.5.10 thereof. All other setting out shall be done by the Contractor in accordance with the conditions of contract. All setting out shall be sufficiently accurate to ensure that the finished surface structure, pipeline or whatever is positioned with regard to line, level or grade within the tolerances allowed for in the relevant specification or called for on the Drawings.

4B.5.16 Measurements of Earthworks

Before work is put in hand, the Contractor and the Engineer shall together survey and take levels in the areas where the work is to be carried out and agree to the surface levels of the materials to be executed or built upon and such agreement shall be recorded in writing and signed by the Engineer and the Contractor. The finished levels of all foundations and trenches invert are also to be taken, agreed and recorded in writing and signed as above described.

4B.6 EARTHWORKS AND SITE WORKS:

4B.6.1 Scope

The work covered by this Section comprises furnishing of all construction plant, labour, equipment, appliances and materials, and performing all operations in connection with excavating, placing, stabilizing and compacting earth (including rock) and disposal of excavated material.

4B.6.2 Reference Standards

The Contractor shall comply with all relevant statutory regulations and standards current at date of Tender, unless otherwise indicated within this Specification.

BS 812	Testing aggregates.
BS 1377	Methods of test for soils for civil engineering purposes.
BS 6031	Code of practice for earthworks.
BS 6187	Code of practice for demolition.
BS 6906	Methods of test for geotextiles.
ASTM D 1557-91	Test method for laboratory compaction characteristics of soils using modified effort (56.000 ft-lbf/ft3) (2,700 KN-m/m3).
ASTM D 4253-91	Test method for maximum index density and unit weight of soils using a vibratory table.
ASTM D 4254-91	Test method for maximum index density and unit weight of soils and calculation of relative density.
ASTM D 698-91	Test method for laboratory compaction characteristics of soil using standard effort (12,4000 ft-lbf/ft3) (600 KN-m/m3).
ASTM D 1556-90	Test Method for density and unit weight of soil in place by the sand-cone method.
ASTM 2487	Test method for classification of soils for engineering purposes.
CIRIA Report 97	Trenching practice.
ASTM A975-97	Standard specification for double-twisted hexagonal mesh gabions and revet

mattresses (metallic-coated steel wire or metallic-coated steel wire with polyvinylchloride (PVC)).

BS 1052 Specification for mild steel wire for general engineering.

BS 443 Specification for testing zinc coatings on steel wire and for quality requirements.

If no standard is specified, the relevant British or International Standard shall apply.

4B.6.3 Definitions

The following terms shall have the meanings hereby assigned to them:

“Topsoil" (sweet soil)	Any surface material capable of supporting vegetation and suitable for use in soiling areas to be grassed or cultivated.
"Bulk Excavation"	Excavation in open cut (excluding Trench Excavation) down to levels specified on the Drawings or otherwise as being the general levels after completion of excavation other than Incidental Excavation.
"Trench Excavation”	Excavation, to levels and limits specified on the Drawings or otherwise, of trenches into which pipes and the like are to be laid.
"Incidental Excavation"	Excavation (generally in small quantities) below or outside the limits of Bulk Excavation and Trench Excavation, but excluding Excess Excavation.
“Excess Excavation”	Excavation outside the limits specified for Bulk, Trench or Incidental Excavation.

4B.6.4 Existing Conditions and Protection

The Contractor shall be deemed to have visited the site prior to submitting his tender and shall have examined the site, records of existing utilities and construction, records of test boring and the sub-surface exploration reports to determine all conditions under which the work will be performed.

The topographical survey of the site and the commencement levels shall be agreed with the Engineer and recorded before starting any excavation.

As Built and record drawings of existing works at the existing WDC’s shall be obtained from the Employer before commencing any excavation at the existing WDC’s.

The existing utilities and existing construction shown on the Drawings (including underground construction) represents all conditions known to the Engineer and are provided to the Contractor in good faith without warranty as to their completeness or accuracy.

Existing pipes and utilities remaining in service, including those remaining in service until after relocation, and relocated utilities are shown on the Drawings.
Before excavating near any existing utilities, the Contractor shall notify the Utility Owner, co-ordinate protective work and comply with the Utility Owner's requirement. The Contractor shall safeguard and protect from damage or movement of any existing services, utilities and utility structures uncovered or encountered which are to remain in service.

Within the limits of excavation, the Contractor shall remove existing pipes, sub-soil drainage systems, conduits, manholes and related items that are to be abandoned and plug open ends with concrete.

The Contractor shall consult the Engineer immediately for directions regarding any uncharted or incorrectly charted pipes or utilities encountered during excavation. The Contractor shall cooperate with the Utility Owners in maintaining their utilities in operation.

The Contractor shall indemnify and save harmless the Employer against any damage due to the Contractor's construction activities caused to any structures, pipes or services adjacent to or under the Site.

The Contractor shall give due consideration to the possible effects on the existing structures of excavation. The Contractor shall pay particular attention to maintenance of thrust restraint to existing pipelines.

The Contractor shall provide proper shoring of the excavation adjacent to structures, roads and walkways to prevent any lateral yield of the soils and loss of foundation support.

The Contractor shall co-ordinate work at existing WDC's with the Employer's Operation and Maintenance Engineers and comply with their requirements.

4B.6.5 Safety and Avoidance of Nuisance

The Contractor shall perform all work in such a manner as to ensure the safety of the Works, the public and adjoining sites and so as to cause as little inconvenience as possible to the public and adjoining Owners.

Temporary barriers shall be provided around the edge of all excavations and stores and material shall be kept away from the edge of excavations so as to allow free movement of labour and staff around the excavations.

The Contractor shall execute earthwork and shoring activities (and Site work generally) in such a manner to ensure that no damage occurs to adjoining property.

4B.6.6 Submittals

The Contractor shall submit the following for the Engineer's review and approval prior to commencing excavation:

i. Information and full details of the procedures proposed for excavating and filling.
ii. Method Statements and shop drawings detailing temporary works relating to excavations including barriers, accesses, lighting, supports, etc.
iii. Details of any proposed temporary batters.
iv. Contractor's record drawings of the ground level survey prior to the start of any earthwork.
v. Information obtained from trial holes ordered by the Engineer.

vi. Record drawings and survey data taken for the purposes of measurement of quantities of excavation or filling. Survey record drawings shall be submitted within seven days of the completion of the survey work recorded on them.

vii. Method statements for excavation and filling, including transport, compaction and processing of materials.

viii. Certified results of laboratory and field tests, including but not limited to, compaction records, borehole logs, piezometer records, in situ density tests, Proctor tests, in-situ soil strength tests, particle size distributions and chemical analysis of ground water.

ix. Program for quality control of earthworks and proposals for the use of off-Site laboratories.

x. Materials proposed for filling:
The Engineer's approval shall not relieve the Contractor of his obligations and liabilities under the Contract and the Contractor shall be responsible for executing the excavations and temporary works in a safe and workmanlike manner.

4B.6.7 Materials, General

4B.6.7.1 Fill Material

Wherever possible, fill materials shall be obtained from the excavations.

Where necessary, the excavated materials shall be screened or processed to comply with the Specified requirements for fill material.

Fill materials shall be free from clods and lumps, organic matter and contain less than 20% (by volume) of calcium carbonate.

The Contractor shall submit details, including test results and samples, and obtain the Engineer’s approval for all fill material.

Except where otherwise Specified or shown on the Drawings fill materials used shall be in accordance with the following table.

Fill Description	Location where used
Selected Excavated Fill	General fill areas such as landscaping areas, including valley areas. Fill on top of reservoirs.
Structural Fill	Fill under foundations of structures. Fill in embankments formed to support structures or roads. Fill to the underside of the boundary wall. Fill to reservoir embankments.
Pipe Bedding and Surround Fill	Pipe bedding material. Pipe surround to 300mm above pipes (or as shown on the drawings).
Trench Fill	Backfilling of trenches above pipe surround.
Free-draining Fill	Reservoir roof drainage layers. Reservoir peripheral drains. Fill to reservoir under drainage blanket and collector drains. Other drains and soakaways.
Slope Protection Fill	Slopes subject to water erosion such as detention pond slopes, outfalls, etc.

Gabion Fill	Gabion unit fill material.
Cement Stabilized Fill	Cement stabilized fill to areas where erosion of the foundation to structures may cause instability of that structure.

4B.6.7.2 Fill Generally

Fill material shall comply with the grading given in table A. Where necessary the Contractor shall process the excavated material at no additional cost to the Employer, to satisfy the grading requirements.

Table A
GRADING OF FILL MATERIALS

BS Sieve (mm)	Percentage by mass passing Sieve Size					
	Free Draining Fill	Pipe Bedding and Surround Fill (Type I)	Pipe Bedding and Surround Fill (Type II)	Selected Excavated Fill, Structural Fill, Trench Fill & Cement Stabilized Fill	Gabion Fill	Sand
300						
200						
150					100	
125				100		
100					0-10	
75				60-100		
28						
20			100			
14	100	100	85-100	10-100		
10	0-100	10-100	50-85	0-100		
5	0-50	0-100	20-40			
2	0		5-20		0	100
0.6		0-100	0-5	0-100		0-100
0.2				0-80		0-80
0.063		0-10		0-10		0-10
0.002		0		0		0

Fill and pipe bedding and surround materials shall not contain ashes, cinder, refuse, rubbish, organic material or the like and shall be free from clods and lumps. The material shall fall within the following Standard Classifications:

	AASHTO	BSCS
Marine Sands	A3	SP
Gatch	A1 / A-2-4	SW, SM
Granular	A1 / A-2-4	GW, GP, SW, SP

Sabkha falling within the AASHTO classification A4 & A6 and BSCS classification ML, CH, CL or MH shall not be used as pipe bedding and surround or fill material.

4B.6.7.3 Selected Excavated Fill

Selected Excavated Fill materials shall be excavated material selected to comply with the particle size distribution shown in Table.

4B.6.7.4 Structural Fill (Controlled Fill)

Structural fill materials shall be excavated material selected to comply with the particle size distribution shown in Table.

Where necessary, processing of the excavated material shall be employed.

4B.6.7.5 Free-Draining Fill

Free-draining Fill shall be formed of hard durable particles and shall be free from clay, silt and organic matter.

Free-draining Fill material, after placement, shall conform to the grading limits specified in Table A. The gradings and materials shall be subject to the approval of the Engineer and they shall not be gap graded.

The aggregate crushing value of the material shall not exceed 30 per cent.

Material for Free-draining Fill shall be provided from an approved source.

Processed excavated material may be used providing that it complies with the Specified requirements.

4B.6.7.6 Boundary Wall Fill

Fill under the boundary wall shall be Structural Fill free from angular or sharp material or organic matter and shall comply with the particle size distribution shown in Table A.

4B.6.7.7 Pipe Bedding and Surround Fill

Pipe Bedding and Surround Fill shall be formed from hard dense granular material complying with the particle size distribution shown on Table A. Sharp particles, which could cause damage to the pipe protection, shall be removed.

Pipe bedding and surround shall be either Type I or Type II of Table ‘A’, at locations as shown on the Drawings.

The material shall be inert to the groundwater or stored water.

Where possible materials shall be selected from excavated materials. Where adequate quantities of excavated materials are not available materials shall be imported from an approved source.

Materials shall be tested in accordance with BS 812: Part 111, and shall have a 10% fines value greater than 50kN. Material retained on a 7mm sieve shall have an index of flakiness less than 25% and an index of elongation less than 45%.

The material shall be free from organic material and clay with a liquid limit exceeding 80 or a plasticity index exceeding 55. It shall be selected to meet the specified requirements including the particular trench conditions.

4B.6.7.8 Cement Stabilised Fill

Cement Stabilised Fill material shall comply with the particle size distribution in Table. The fill material shall be provided by the Contractor from an approved source. Material emanating from the excavations may be used providing that it complies with the Specified requirements for Cement Stabilised Fill.

The quantity of cement to be added to the fill material, measured as a percentage of its dry weight, shall be a minimum of 5% sulphate resisting cement. The material shall be placed and compacted within 2 hours of mixing.

4B.6.7.9 Trench Fill

Trench Fill materials shall be selected excavated material complying with the particle size distribution shown in Table. The material shall be compacted at a moisture content within the range of four percent (4%) below optimum to optimum, in layers not exceeding 150mm thick, to at least 90% of maximum dry density obtained in the BS compaction test described in Clause 3.3 of BS 1377: Part 4: 1990. Trenches under access tracks and existing or new highways and verges and car parking shall be compacted to 95% to 98% of the maximum dry density as detailed on the drawings.

4B.6.7.10 Gabion Fill

Gabion Fill shall comply with the particle size distribution shown in Table A. The 10% Fines Value shall be greater than 50kN. The 10% Fines Value shall be the value determined in accordance with BS812 with samples in a soaked condition.

The Gabion Fill shall be obtained from an approved source. Details of the proposed material including source, certified test results and samples shall be submitted for the approval of the Engineer.

4B.6.7.11 Borrow Fill (Additional Fill)

If the surplus suitable material obtained from excavations is less than the quantities required for filling, the Contractor shall supply filling material at his own responsibility from borrow pits, provided such borrow pits are approved by the responsible Governmental Authorities of Kuwait.

The Contractor shall obtain and supply to the Engineer representatives samples from the borrow pits he intends to use. The Engineer will be afforded the opportunity to be present during the sampling operations. The Engineer will carry out the necessary laboratory (and, if required, field) testing to

establish the suitability of the material for filling work and will advise the Contractor whether such material is acceptable and whether the borrow pit is an approved source of borrow material.

The Engineer will test samples of the approved borrow pits material actually being imported onto the site, and should such material fail to meet the requirements of these specifications, approval to the use of the borrow pits will be withdrawn and the Contractor shall immediately cease importation from the borrow pits until such time as the Engineer may approve alternative sources of material from within the same borrow pits based on sampling and testing as specified above.

The Engineer will decide whether the material already imported from the concerned borrow pits can remain as placed on the site, or whether the Contractor shall remove and replace the said material at his own expense.

Over-burden and any unsuitable top layers shall be striped and stockpiled to the satisfaction of the Engineer. Upon completion of excavation, the Contractor shall replace the over-burden and unsuitable material, smooth the surface and leave the area clean and tidy to the satisfaction of the Engineer. The Employer shall not be responsible for any claims for compensation or complaints submitted by the land owners on account of such works and the Contractor shall bear full responsibility for and shall indemnify and keep indemnified the Employer against all such claims.

The Contractor's haul and traffic arrangements will be subject to the Engineer's approval before the work may be commenced.

4B.6.7.12 Geotextiles

Geotextiles shall have the mechanical and hydraulic properties of the geotextile types shown on the following table and be from a manufacturer approved by the Engineer.

The Contractor shall provide evidence to the Engineer, before the geotextile is incorporated in the Permanent Works, that the geotextile will be sufficiently durable to maintain its integrity for the Specified working life of the material. Geotextiles shall be resistant to naturally occurring chemical compositions, unaffected by bacteria and fungi, non-reactive to changes in temperature and not harmed by short term exposure to sunlight.

Mechanical Properties for Geotextile

Mechanical properties (Units)	**Value**
Design life (years)	60
Minimum Breaking Load (kN/m) BS 6906	9
Extension at max. load (%)	40
Minimum Burst strength CBR (kN)	1.675
Minimum Permeability ($l/m^2.s$) at 10cm constant head	>30
Pore size 90% summation (um)	100-300

4B.6.7.13 Polymeric soil stabilizers

It shall consist of a liquid co-polymer with an acrylic base that contains a minimum of 55% solids. The polymeric compound shall be handled and mixed in a manner that will not cause foaming or shall contain an anti-foaming agent. The polymeric emulsion shall not exceed its shelf life or expiration date; manufacturers shall provide the expiration date. Polymeric soil stabilizer shall be readily miscible in water, non-injurious to seed or animal life, non-flammable, shall provide surface soil stabilization for various soil types without totally inhibiting water infiltration, and shall not re-emulsify when cured. The applied compound shall air cure within a maximum of 36 to 48 hours. Liquid co-polymer to water dilution ratio and application ratio for the required area, shall be as per soil conditions, manufacturer's recommendations and to the approval of MEW Engineer. Material data sheet to be submitted.

4B.6.8 Water

An adequate supply of water for use in constructing earthworks in accordance with these Specifications shall be provided. The use of fresh water and brackish water will be permitted for all earthwork operations (provided that the total dissolved solids do not exceed 4500 parts per million) unless otherwise Specified.

4B.6.9 Unsuitable Material

When the specified levels or limits of any excavation are reached, the Engineer will inspect the ground exposed and if he considers that any part of the ground is unsuitable he may direct the Contractor to excavate further. Such further excavation shall be refilled to the specified levels or limits with concrete, Structural Fill or selected imported material as directed.

Should the material forming the bottom or side of any excavation, while acceptable to the Engineer at the time of inspection, subsequently become unsuitable during the progress of the Works then the Contractor shall remove the unsuitable material and excavate further to a sound surface. The voids shall be filled with material as instructed by the Engineer.

4B.6.10 Control of Fill Material

Should material selected as fill material become unsuitable to the Engineer for any reason including exposure to weather conditions, flooding, contamination by other materials or segregation during the progress of the Works, then the Contractor shall remove the material and replace it with approved material.

4B.6.11 Quality Control

Compliance of the fill materials with the requirements of this section prior to use in the Works shall be demonstrated by means of the specified test procedures.

Compliance testing shall be carried out by the Contractor on a routine basis as specified and as required by the Engineer and shall submit reports specified in this Section.

4B.6.12 Soils Testing

4B.6.12.1 General

Field and laboratory tests shall be performed to ensure:

- Fill material complies with the specified grading limits.
- Fill is compacted to the specified limits of dry density.
- Fill material complies with the specified plasticity index (where specified).
- Fill complies with the requirements for maximum salt and carbonate content.
- Sub-grades comply with the specified requirements.
- Suitability of the fill in accordance with the specifications.

4B.6.12.2 Testing

Testing shall be to BS 1377:Parts 1 to 9, 1990 unless otherwise approved.

Particle size distribution (grading) shall be determined by the appropriate variation of Method 9 of BS 1377:Part 2, 1990. Maximum dry densities and optimum moisture contents for compaction control by relative compaction shall be derived using either Method 3.3 or Method 3.4, as appropriate, of BS 1377: Part 4, 1990.

Fill material density shall be determined by the sand replacement method generally in accordance with Method 2.2 of BS 1377: Part 9, 1990 or a similar approved test.

Nuclear density testing equipment may be used in place of sand replacement tests for measuring in-situ densities provided that:

i. The Contractor is able to demonstrate to the satisfaction of the Engineer over a reasonable period that the results obtained with nuclear density equipment correspond with results obtained at the same time using sand replacement methods.

ii. At least one sand replacement test is carried out for every ten nuclear density tests to check that the nuclear density equipment is properly calibrated and continuing to provide accurate results.

The Engineer may at any time without advance warning withdraw approval to use nuclear density testing equipment should there be any doubt as to the accuracy of results obtained.

4B.6.12.3 Samples

Samples for laboratory testing of maximum dry densities and optimum moisture contents shall be taken adjacent to and including in-situ density test locations.

The location of each field test or sampling point shall be to the approval of the Engineer. The location of each test shall be properly recorded and copies of such records submitted to the Engineer weekly or at such intervals as agreed with the Engineer.

4B.6.12.4 Results

Test results and copies of calculations shall be submitted promptly upon completion and a minimum of 5 working days before commencement of compaction of the fill.

4B.6.12.5 Frequency of Testing of Fill Materials

4B.6.12.5.1 Pipe Trenches

In trenches, the Contractor shall carry out tests on Pipe Bedding & Surround and on backfill on each 1m depth at the rate of six particle size distribution tests and six laboratory compaction control tests for each kilometer of pipeline trench and at any position required by the Engineer.

Where in the opinion of the Engineer consistent density and particle size distribution results occur then the testing frequency may be reduced to a rate of three particle size distribution tests and three laboratory compaction control tests for each kilometer of pipeline trench.

In-situ density and in-situ moisture content testing of Pipe Bedding & Surround and backfill shall be performed at the rate of one test per layer per 100m length of trench.

If the first time pass rate exceeds 80%, the frequency may be reduced to one test per layer per 200m length of trench.

If the first time pass rate exceeds 90%, the frequency may be reduced to one test per layer per 400m of trench, all subject to the approval of the Engineer.

4B.6.12.5.2 Structural and Other Fill

The frequency of testing for other fill materials shall be as shown in the following Table.

Table B

FREQUENCY OF TESTING OF FILL

Material	Minimum frequency of control testing required per 1,000m^3 of fill placed, or per day where the volume of fill placed on that particular day is less than 1,000m^3 for fill type: Test type: **A** **B** **C** **D**
Structural Fill	1 2 2 1
Selected Excavated Fill	1 2 2 1
Cement Stabilised Fill	2 2 2 1
Gabion Fill	3 - - -
Free-draining Fill	4 - - -
Slope Protection Fill	2 - - -

Test type:
A – Particle size distribution or grading
B - In situ dry density by sand replacement method
C - In situ moisture content
D – Maximum dry density and optimum moisture content (BS1377)

4B.6.12.6 Fill Material Approval Criteria

Compacted fill materials shall have an in-situ dry density equal to or greater than the percentage of the maximum dry density specified for the relevant type of fill. Where required, the compacted fill materials shall also have an in-situ moisture content within the range specified.

4B.6.13 Excavation

4B.6.13.1 Excavation in Any Material

Excavate in any material including rock to the lines and elevations as required.

The Contractor shall be deemed to have studied the site investigation data, visited the site and collected all additional data necessary to evaluate the nature of the Site materials and shall be deemed to have included the costs of excavation in any material in his tender. No additional payments shall be made for excavation in rock, removal of boulders, excavation of loose sand or for excavation in any other materials whether natural or artificial.

4B.6.13.2 Fossils and Antiquities

The Contractor shall immediately cease work, other than any works necessary for safety and protection, and shall inform the Engineer of any fossils, coins, articles of value or antiquity, or anything of geological or archaeological interest found.

4B.6.13.3 Excess Excavation

Excavations below the levels shown on the Drawings or specified shall, at the Engineer's discretion, be backfilled with Type V (sulphate resistant) concrete of approved strength, unless instructed otherwise by the Engineer.

Where concrete is to be cast against undisturbed ground, Excess Excavation shall be backfilled with mass concrete of the same grade as specified for the structure, or, where there is no adjacent fill, with Selected Excavated fill materials similar to those in the adjacent filled areas, constructed to the same specifications.

Excess excavation around structures for working space shall be backfilled with approved compacted fill.

Excess excavation under roads and paved areas shall be backfilled with Structural Fill.

4B.6.13.4 Inspection by the Engineer

When the specified levels or limits of any excavation are reached, the Engineer will inspect the formation and if he considers that any part of the ground is unsuitable he will direct the Contractor to excavate further and backfill to the specified levels or limits with concrete, compacted pipe bedding material or compacted fill.

Should the material forming the bottom or side of any excavation become unacceptable due to exposure to weather conditions or due to flooding or have become puddled, or soft or loose or otherwise become unsuitable during the progress of the Works, then the Contractor shall re-excavate and fill to the approval of the Engineer.

4B.6.13.5 Unsuitable Formations

In case, unsuitable bearing soil is encountered at subgrade elevations shown, the Engineer may require the removal of unsuitable soil and extension of foundations, blinding concrete and slabs on grade. The cost of this extra excavation and all relevant works will be reimbursed to the Contractor at contract rates.

The Contractor shall inform the Engineer of any formation or material which is unsuitable.

4B.6.13.6 Formations for Embankments

Formations to receive road embankments, structural fill and cement stabilised fill shall be excavated to sound material giving the bearing capacity as specified on the Drawings or as directed by the Engineer.

4B.6.13.7 Explosives and Blasting

The use of explosives will not be permitted.

4B.6.13.8 Trial Holes

The Engineer may direct that trial holes are excavated in advance of other excavation to such dimensions and depths as he shall order to obtain information required by the Engineer. Trial holes so ordered by the Engineer shall be measured for payment.

Trial holes excavated by the Contractor to determine the position of underground pipes, services, obstructions or for any other reason shall be excavated and reinstated at no extra cost to the Employer.

The Contractor shall refill and reinstate trial holes immediately to the approval of the Engineer.

4B.6.13.9 Excavations - Support and Working Space

Provide effective support for the sides and ends of all excavations to prevent any fall or run from any portion of the ground outside the excavation and to prevent settlement or damage to structures adjacent to the excavation.

Remove wind-blown deposits and accumulated materials from excavations at no extra cost.

Excavations with sloping faces, without shoring, shall be to stable slopes and heights. Details and calculations shall be submitted to the Engineer for approval.

4B.6.13.10 Dewatering Excavations

Excavations shall be kept free from water whether emanating from rainwater, surface runoff, groundwater or other sources such that the works are constructed in dry conditions.

All necessary measures shall be taken to prevent ingress of water to excavations and trenches from surface rainwater runoff.

Any foundation material rendered unsuitable by water or exposure shall be removed and replaced with mass concrete.

Where required dewatering shall be maintained for as long as necessary to prevent flotation of any pipes or structures.

Disposal of water shall be to the Engineers approval.

4B.6.13.11 Disposal of Excavated Material Off the Site

Material excavated from the Site shall, as far as possible, be re-used on the site as fill materials.

All surplus material or material which does not meet the required specification shall be removed from the Site and disposed of.

The Contractor shall identify suitable sites for disposal and obtain all necessary relevant permissions and permits from the Municipality, other relevant authorities, owners or occupiers and the approval of the Engineer.

Disposal shall not create a nuisance or interfere with, or obstruct, or endanger, or contaminate any property or sources of water.

The completed disposal sites shall be graded and shaped to harmonise with their surroundings and shall comply with the requirements and regulations of any planning, health, or other duly constituted authority having an interest therein.

Material resulting from clearing and grubbing operations must not be burnt on the site. Dispose of all such material legally off the Employer's property.

4B.6.13.12 Temporary Spoil Tips

Temporary spoil tips shall be so shaped as to maintain stability and good drainage at all times, and shall not result in the deposition of wind-blown sand across the site. The limits of such temporary spoil tips shall be to the approval of the Engineer.

4B.6.13.13 Trimming Excavations

Excavations for foundations or within which concrete is to be cast against undisturbed ground shall not be completed to the final level or profile until immediately before construction of the permanent works is started. A minimum of 100mm of excavation shall be left for final trimming.

Shattered and loose material shall be removed from the bottom of excavations.

4B.6.13.14 Formations for Foundations and Embankments

Formations to receive foundations, road embankments, structural fill and cement stabilised fill shall be excavated to sound material with the bearing capacity as specified on the Drawings or as directed by the Engineer.

The Contractor shall inform the Engineer of any formation or material which he considers to be unsuitable.

4B.6.13.15 Formations for Ground Slabs, Paving and Compacted Embankments

The top 300 mm of the formation to receive ground slabs paving materials and compacted embankments shall be scarified watered and compacted to 95% of maximum density.

4B.6.13.16 Formations in Trenches

Any unsound material in the bottom of trenches shall be removed and the void filled with compacted bedding material or concrete Class C15 as directed by the Engineer.

All shattered and loose material shall be removed so that the bedding rests on a sound clean foundation.

Any rock or hard material shall be excavated to provide a minimum clearance around the pipe or service of at least 150mm. No rock, boulder, stone or hard material shall protrude into this minimum clearance.

4B.6.13.17 Site Clearance

All areas of the Site from which material is to be excavated or upon which filling (including spoil tips) is to be deposited shall be cleared to the extent required by the Engineer of all buildings, walls, gates, fences and other structures and obstructions and of all bushes, hedges, trees, stumps, roots and other vegetation except for trees marked for preservation.

Material so cleared shall so far as suitable be reserved and stacked for the Employer's use

4B.6.13.18 Hedges and Trees

No trees or hedges shall be uprooted or cut down without prior approval of the Engineer.

4B.6.13.19 Stripping Top Surface

Where ordered by the Engineer the top surface including topsoil, organic or unsuitable founding material shall be stripped, to such depths and over such areas as he may direct, as a separate operation prior to any further excavation which may be required.

4B.6.13.20 Removal of Unsuitable Material

Surface deposits of gypsum and salts shall be excavated and disposed of off Site.

The depths of excavation shall be as instructed by the Engineer.

Unsuitable materials shall not be allowed to contaminate suitable material.

4B.6.13.21 Excavation for Slabs on Grade

Subgrades below slabs on grade shall be approved by the Engineer before proceeding with the construction.

Slabs on grade shall be founded on compacted soil at elevations indicated on the Drawings and as approved by the Engineer.

Subgrades to receive slabs on grade shall be level and free of loose rock, debris and standing water prior to acceptance for placing blinding concrete.

4B.6.13.22 Excavation for Paved Areas and Kerbs

Subgrade shall be approved by the Engineer before proceeding with construction of pavements and kerbs.

The top 300 mm of subgrade resulting from excavation shall be free of unsuitable materials and be equal to the following percentages of maximum density at optimum moisture when tested in accordance with ASTM D1557:

i. Under paved areas and kerbs - 95%
ii. Under slab on grade - 95%

If the subgrade does not meet the above requirements after proof-rolling, compact the subgrade by rolling with suitable compaction equipment to obtain the density specified.

4B.6.13.23 Excavation for Isolated and Continuous Foundations

Excavation for isolated and continuous foundations shall be to the dimensions shown on the Drawings. The ground to receive blinding concrete shall be level and free of loose rock, loose soil, debris and standing water.

4B.6.13.24 Trench Excavation, Generally

Trench excavation means excavation of trenches into which pipes, cables or other services are to be laid.

Trench excavation shall be carried out by such methods and to such lines, dimensions and depths as shall allow for the proper construction of the works.

No excavations with battered sides will be permitted in public highways or within 30 meters of any building or other structure.

Every precaution shall be taken to prevent slips and falls of ground in the excavations.

Any rock or other hard material in trench excavation shall be excavated so that the minimum clearance around the pipe provides for the specified thickness of bedding haunching and surround to the pipe.

Trench excavation shall not be started until the pipes to be laid in that length are available on the Site.

4B.6.13.25 Trench Widths

Maximum trench widths shall be as shown on the Contract Drawings or if no dimensions are shown the width shall be the minimum necessary for the installation of the pipe or service.

In the event of any trench exceeding the specified width the Engineer may order the use of an alternative type of bedding and fill or such other remedial measures as in his opinion are necessary.

Where any trench for a pipeline is excavated with battered or stepped sides, the bottom of the trench from the formation to a point 300mm above the crown of the pipe shall be formed with vertical sides at the maximum widths.

4B.6.13.26 Trimming Trench Excavations

The formation of the trench bottom shall be trimmed to the required level. All shattered and loose material shall be removed from the bottom of the trench excavation so that the bedding material rests on a sound and clean foundation.

Any unsound material in the bottom of any excavation shall be removed as directed by the Engineer and disposed of. The void shall be filled with compacted selected excavated material or concrete Class C15/40 as directed by the Engineer.

4B.6.13.27 Trenches Not to Be Left Open

Trench Excavation shall be carried out expeditiously and, subject to any specific requirements of the Contract, the refilling and surface reinstatement of Trench Excavations shall be commenced and completed as soon as reasonably practicable after the pipes, cables or service have been laid and tested.

4B.6.13.28 Trench Excavation in Roads and Footpaths

Excavation and other work carried out within any footpath, highway or road shall be completed as rapidly as possible and with every care for the safety of the public.

The Contractor shall take all necessary precautions, including provision of continuous support of the side of the excavation, from the time when excavation is begun until the refilling of the trench is completed, to ensure that there is no disturbance of the adjacent road or road foundation.

Road drainage shall be maintained in operation without obstruction during the progress of the work.

4B.6.14 Filling and Compacting

4B.6.14.1 Materials

Materials for fill and backfill shall be obtained from the excavations on Site, if acceptable. All fill materials shall be approved by the Engineer prior to use.

4B.6.14.2 Control of Moisture

Soil shall not be compacted when the moisture content varies more than 3% from the optimum moisture content.

Where necessary the moisture content of the fill shall be adjusted, either by drying out or adding of water. After such drying out or adding of water the fill shall be thoroughly mixed until the moisture content is suitable.

The Contractor shall suspend compaction operations when satisfactory results cannot be obtained because of rain, drying winds or other unsatisfactory conditions.

4B.6.14.3 Placing

The Contractor shall place fill materials in horizontal loose layers in such manner as to produce a uniform thickness of material. Placement shall start in the deepest area and progress approximately parallel to the finished grade. Thickness of layers after compacting shall not exceed 200mm except adjacent to structures where the maximum layer thickness shall be 150mm. The Contractor shall ensure

that a good bond is achieved between layers of fill and, unless otherwise directed by the Engineer, no material shall be placed on previously compacted layers until the surface has been harrowed or otherwise broken up and, if necessary, watered. Any condemned material shall be removed.

The moisture content of compacted material shall be controlled within the range specified by either drying or adding water. The material shall be thoroughly mixed to ensure the moisture content is uniform.

No fill material shall be placed on areas where free water is standing or on surfaces which have not been approved by the Engineer.

4B.6.14.4 Compaction

Each layer of fill shall be compacted to achieve the following percentages of maximum density at optimum moisture when tested in accordance to Clause 3.3 of BS1377: Part 4: 1990.

Location	% Maximum Density
• Under Paved Areas and Kerbs	95
• Under Slabs on Grade	95
• General Grading/ Bulk Fill	90
• Selected Excavated Fill	90
• Structural Fill	95
• Under boundary walls	95
• Reservoir Foundation Fill	95
• Backfill to Structures	95

Compaction adjacent to structures shall utilise light compaction plant and thin layers to achieve a compaction of 95% of maximum density.

Compaction plant shall be approved by the Engineer.

4B.6.14.5 Filling, General

Where different types of fill material are to be placed in separate layers or wedges the work shall be carried out so as to prevent mixing of the different types of material.

Any material not complying with the specified density or moisture content shall be excavated and replaced with suitable material notwithstanding the fact that it may have been covered by subsequent layers of fill or concrete.

Allowance shall be made for any settlement of fill that may occur before the end of the Maintenance Period. The Contractor shall at the end of the Maintenance Period remove any excess material or make up any deficiency.

No material shall be placed on a previously compacted layer until the surface has been scarified and, if necessary, watered. The Engineers approval shall be obtained prior to placing fill on a previously compacted area.

Embankments shall be overbuilt by a horizontal distance of not less than 300mm and shall then be trimmed to the final profile.

Fill to the reservoirs' walls shall not be carried out until the reservoir has passed all prescribed water tightness tests.

Fill material shall generally be obtained from excavations and shall comply with Table A. Where there is insufficient suitable excavated material for filling, the Contractor shall:

i. Carry out such work as may be necessary to sieve or otherwise render the excavated material suitable, or,
ii. Transport suitable material from excavations elsewhere ('overhaul'), or,
iii. Excavate and transport material from suitable borrow areas, or,
iv. Import suitable material.

Processing, overhaul and import of materials shall be subject to the approval of the Engineer and shall be at no additional cost to the Employer.

Approval of the proposed surface shall be obtained prior to the Contractor placing fill on a previously compacted area. The Contractor shall carry out all necessary remedial work promptly as directed by and to the satisfaction of the Engineer.

Filling shall proceed in such a manner that there is always a general fall across the filling surface towards the lower contours.

When the weather is such that in the opinion of the Engineer, it would adversely affect the placing of fill, all filling shall be stopped. In wet weather, fill material shall be so placed as to maintain adequate drainage and to prevent accumulation of water

4B.6.14.6 Placing and Compaction of Selected Excavated Fill

Selected Excavated Fill shall be compacted to a dry density not less than 90% of the maximum dry density. During compaction, the material for fill shall have a uniform moisture content between the range 4 percent (4%) below the optimum moisture content to optimum moisture content.

4B.6.14.7 Placing and Compaction of Structural Fill

Structural Fill shall be compacted to a dry density not less than 95% of the maximum dry density. During compaction, the material for Structural Fill shall have a uniform moisture content between the range 3 percent (3%) below the optimum moisture content to optimum moisture content.

4B.6.14.8 Placing and Compaction of Reservoir Formation Fill

Reservoir Formation Fill shall be compacted to a dry density not less than 95% of the maximum dry density. During compaction, the material for Reservoir Formation Fill shall have uniform moisture content between the range 3 percent (3%) below the optimum moisture content to optimum moisture content.

4B.6.14.9 Placing and Compaction of Pipe Bedding and Surround

Pipe Bedding and Surround shall be compacted to not less than 90% of the maximum dry density obtained in the BS Compaction described in Clause 3.3 of BS1377: Part 4: 1990. During compaction, the material for Pipe bedding & Surround shall have a uniform moisture content between the range of four per cent (4%) below optimum to optimum moisture content.

Heavy mechanical compactors shall not be used within 300mm of the pipe crown.

Pipe Bedding shall be laid over the full width of the trench to provide a uniform bed for the pipes. The bedding shall be compacted and accurately shaped so that the pipe is supported along the entire barrel length. The minimum thickness of the bed below the pipe barrel at any point shall not be less than that shown on the Drawings. The minimum thickness of bedding below joints shall be 50mm.

Recesses shall be formed in the bedding to accommodate joints and any specified wrapping.

Surround material shall be rammed and compacted in layers to a minimum depth of 300mmm above the pipe crown.

4B.6.14.10 Placing and Compaction of Backfill to Trenches

Trenches shall be backfilled with selected excavated material complying with clause 5.6.4.

The material shall be compacted at a moisture content within the range of four per cent (4%) below optimum to optimum in layers of between 100mm and 300mm thickness, to at least 90% of maximum dry density obtained in the BS Compaction described in Clause 3.3 of BS1377: Part 4: 1990. Trenches under access tracks and/or highway verges shall be compacted to 95% of the maximum dry density.

4B.6.14.11 Placing and Compaction of Free-draining Fill

Free-draining fill shall be placed carefully to avoid breaking up the material particles or changing the material particle size distribution. No compaction shall generally be required.

Where free-draining fill is to be placed over geosynthetic materials such as geotextiles and geomembranes, all methods, plant and equipment employed to place free-draining fill over such materials shall be suitable for the purpose without causing damage to the geosynthetics.

4B.6.14.12 Placing, Mixing and Compaction of Cement Stabilised Fill

Cement Stabilised Fill shall be properly mixed to ensure that the appropriate quantity of cement is uniformly distributed throughout the fill material.

Cement stabilisation shall not be carried out during periods of rain or when rain is imminent. During processing only sufficient water shall be available in the material to hydrate the cement and enable satisfactory mixing and compaction to be achieved. Any added fresh water shall be applied uniformly and properly mixed by appropriate means to the approval of the Engineer.

Each layer of stabilised material shall be compacted as soon as possible after laying and in any case within 2 hours following the mixing of the cement into the material to be stabilised.

Compaction shall be carried out by a minimum of 5 passes of a 3 tonne vibratory roller. The compacted layer shall not be greater than 150mm in thickness. Other methods of compaction may be acceptable, subject to approval by the Engineer.

4B.6.14.13 Backfilling and Fill to Structures

The timing and rate of placing and method of placing and compaction of backfill and fill to structures shall be such so as not to over-stress, weaken, damage or otherwise endanger the structure. The structure shall be backfilled/filled uniformly in layers so as to avoid eccentric or differential loads and not to endanger the stability.

The placing of material around the walls of basements, reservoirs and tanks shall commence only after the walls and floor have been completed and have attained their specified strength

Fill to pipe chambers and thrust blocks prior to testing shall be to the maximum levels possible whilst maintaining the pipe joints accessible for inspection.

4B.6.14.14 Reservoir Wall Stability

The reservoir walls rely on passive ground resistance for stability, to prevent movement due to internal hydrostatic pressures or external earth pressures.

The wall base bearing faces as shown on the Drawings shall be cast against undisturbed ground. Except as shown on the drawings, no excavation or disturbance of the ground in front of the bearing faces shall be permitted for a distance from the bearing face of at least 12m. In the event of such excavation or disturbance, the original ground shall be replaced with cement stabilised fill, mass concrete or other material of a strength and density at least equal to that of the original ground as directed by the Engineer.

4B.6.14.15 Reservoir Testing

The reservoir shall be subjected to water-tightness testing prior to backfilling of the walls as described in Section 01701 of the specification.

4B.6.14.16 Handling and Placement of Geotextiles

Geotextiles shall be protected at all times against mechanical or chemical damage. Those geotextiles which are susceptible to damage by light shall be stored under cover.

Geotextiles shall be laid and lapped or joined as specified or in accordance with the manufacturer's recommendations. However, where lapping is employed adjacent sheets or strips of geotexile shall be overlapped by at least 300mm. The layer of material on which the geotextile is to be placed shall not have protrusions or sharp projections which are likely to damage the material during installation or in service. The method of installation shall ensure that the geotextile is in continuous contact with the surface on which it is to be placed and the geotextile shall not be stretched or bridged over hollows or humps. Operation of construction plant directly on the installed geotextiles will not be permitted. Care shall be taken in placing fill material to avoid damage to the geotextiles. Any damaged material shall be replaced or repaired to the approval of the Engineer.

4B.6.15 Reinstatement

4B.6.15.1 General

Surfaces shall be restored to the original condition or to a condition similar to that of adjacent ground not affected by the works. Reinstatement shall be completed within three weeks of the completion of the earthworks.

4B.6.15.2 Surface Reinstatement of Roads

All permanent and temporary reinstatement of roads shall be constructed generally in accordance with Sections I, II, III and IV of the Technical General Specification for Roads and Drainage, Ministry of Public Works (MPW), Government of Kuwait with the following qualifications:

- Reinstatement shall be to a standard at least equal to that immediately before the Contractor first entered thereon.
- Road sub-base shall comprise natural mineral material conforming to gradation type C as defined in Clause 301.4.
- Road base shall be a sand asphalt mix type A as defined in Clause 302.03.
- Asphaltic surfacing shall comprise a base course of asphaltic concrete Type I and a wearing course of asphaltic concrete Type III as defined in Clause 401.03.

  The base course shall be applied, spread and compacted in one layer of shingle sand bonding material mix in accordance with the Ministry of Public Work's Specification. (Mix 30% and 70% shingle). The minimum compaction density shall be 95% AASHO. The thickness of base course shall be the same as the base course of the existing road (150mm. minimum).

  On the surface of the previous base course the Contractor is required to supply, heat and spray under pressure at the rate of 1½ Kg/m^2 a prime coat for bonding new surfaces with the old one.

  On main roads the Contractor is required to supply, spread and compact one layer of a second asphaltic base course of minimum thickness of 100mm. The mix shall be in accordance with MPW Specification.

  The Contractor shall supply, spread and compact a layer of asphaltic concrete mix as a wearing surface of 60mm thick for main roads or 40mm thick for secondary roads.

After the issue of the Certificate of Completion, maintain the surface of paved trenches and adjacent kerbs and gutters, sidewalks, fences, sod and other disturbed surfaces for a period of 12 months thereafter. The Contractor shall maintain for 12 months areas that have been paved and sidewalk tiles that have been replaced. Maintenance shall be done in a manner satisfactory to the Engineer.

4B.6.15.3 Reinstatement of Footpaths

Footpaths adjacent to carriageways shall be reinstated, where applicable, with pre-cast concrete sidewalk tiles on 100mm thick Class C25/20 concrete bed.

Pedestrian areas shall be paved with pre-cast concrete sidewalk tiles laid on 25mm of clean sand bed on 100mm of good quality clean hardcore which has been spread leveled and compacted. Bedding sand shall consist of clean non-plastic sand, with a maximum size of 6mm. It shall not have more than 10% passing the number 200 sieve.

After laying the sidewalk tiles in a true and square fashion, joints between the flags shall be grouted with cement mortar. The paved area shall be brushed and cleaned after grouting is complete. Mortar for jointing the pre-cast sidewalk tiles shall consist of one part by volume of cement and two parts by volume of natural sand or crushed stone to the grading of Table 2 of BS 1200.

Kerbstones shall be reinstated, where applicable, using pre-cast concrete kerbstones. They shall be bedded on, and backed with, C15/40 plain concrete all to the requirements of the Technical General Specification of the Roads Department of the Ministry of Public Works, Government of Kuwait.

4B.6.16 Disposal of Surplus

The Contractor shall be responsible for all surplus soil or other excavated material not required or not suitable for re-use, and shall follow the Engineer's instructions with regard to such surplus. The Engineer may require the Contractor to transport and deposit such surplus at any specified tip or tips and may instruct the various types of materials to be stacked separately, or he may instruct the Contractor to dispose of the surplus at a tip to be obtained by the Contractor himself and all the Engineer's instructions in this respect shall be carried out by the Contractor at no extra expenses to the Employer.

4B.6.17 Roads and Pavements

4B.6.17.1 Standard Construction

Except where specified otherwise on the Drawings or directed by the Engineer, all roads, turning circles, yards and similar areas which are required to be asphalt surface shall be constructed according to the Standard cross section shown on the Drawings. The road base shall be 20 cm. thick cement stabilized gatch shall also be provided. This sub-base shall be of a thickness directed by the Engineer but shall not be greater than 20 cm. The asphaltic concrete base course shall be 6 cm thick in two layers. The wearing course shall be 6 cm thick but shall not be applied until just before the handing over date and after all the construction works have been completed. On either side of roads concrete kerb stones shall be laid with regular drainage outlets.

4B.6.17.2 Preparation of Subgrade

The existing ground shall be cut or filled and compacted to the required level to cross-falls and gradients and any exposed sides or edges of excavation or filling shall be properly and evenly graded to the required slopes.

Where directed by the Engineer, all pot holes or soft spots below formation level shall be excavated out and filled with gatch or other approved material well watered and compacted in 15 cm. thick layers.

In areas of fill, approved material shall be deposited and spread in 15 cm. thick layers. The moisture content shall be controlled close to optimum and each layer shall be compacted by means of a 10 to 12 ton smooth wheeled or other approved roller to 90 percent of the maximum density of the material as determined by ASTM D1557 (modified AASHTO) and to 95 percent for the last two layers below the sub graded level. In cuttings, the formation shall be shaped, graded and compacted as above to an even and uniform well-filled surface true to the required falls, crossfalls and gradients.

4B.6.17.3 Stabilized Gatch Base

Gatch for road and yard bases must be approved by the Engineer and obtained from carefully selected deposits. Gatch, really available throughout Kuwait is a sand/clay mixture and the material should be selected with a fine content of about 25 percent and with the sand fraction well graded. It should give a modified AASHTO compaction of 125 lb/cu.ft. and a corresponding California Bearing Ratio in excess of 100 percent. The gatch is to be stabilized with the addition of 4 percent of ordinary Portland cement and shall be well graded and free from organic matter and any other foreign material. The base shall be laid so as to extend beneath the concrete kerbs and shoulders of the road yard.

The overall depth of the gatch/cement mixture shall be laid to the required falls and gradients in at least two layers of equal thickness each rolled and consolidated at optimum moisture content with a 10 to 12 ton rubber-tyred roller.

In heavy compaction, optimum moisture content is about 7 percent(10percent in case of lighter rollers) and as the natural moisture content is usually between 3 percent and 5 percent, a small amount only of water need to be added. Watering must be carefully controlled because the low plasticity index of the gatch leads to a rapid fall in the strength of the formation as minimum moisture content is exceeded. Each layer shall be tested for moisture content and addition of water if required shall be carried out by spraying with approved mechanical equipment.

Rolling shall continue until a density of at least 95 percent modified AASHTO is reached and a dense mechanically stable road base is produced with a well shaped and close-texture surface. Tests for compaction shall be carried out at frequent intervals during the preparations of the formation and whenever required by the Engineer. The Contractor shall be responsible for the supply of all necessary testing equipment labour etc. for the carrying out of the tests and he shall render all practical assistance and attendance upon the Engineer and the Employer's technicians during the testing operations and it shall be deemed that his prices include for the supply of such equipment labour etc.

Gatch bases must be kept dry and after rain no surfacing to be applied until the formation has dried out. In certain low-lying areas and areas where the water table is especially near the surface, the Engineer may direct an alternative form of road construction i.e. sand-gravel mixture.

4B.6.17.4 Asphaltic Concrete Surfacing

The asphaltic concrete base course shall be laid in one layer 6 cm. thick, and shall consist of the following materials in the percentage by weight of the total mix indicated:

- 5% bitumen.
- 5% cement filler.
- 25% sand
- 30% fine. Gravel (1/8 – 1/2 inch)
- 35% coarse gravel (3/4 -1.1/2 inch)

The bitumen shall be residual asphaltic bitumen with a penetration of 60 to 70 at 25^0C in accordance with B.S.1621 to be obtained from the Kuwait Oil Company or other approved supplier.

The filler shall be ordinary Portland Cement as specified in clause 4B.7.3 of this Specification.

Sand shall be obtained from selected desert pits approved by the Engineer, and shall have the following grading:

B.S. SIEVE	% PASSING
7	95-100
25	75-98
72	15-58
200	3-5

Gravel must be obtained from an approved source and be well graded within the limits specified.

Tests shall be carried out on the proposed mixes and the Engineer shall have the right to change the percentage specified above for the composition of base course and wearing course surfacing and sand grading should he consider it advisable. The wearing course shall be laid after all construction and other work on the site has been completed and immediately prior to the handing over of the site to the Employer**.**

The finished asphaltic concrete shall comply with the Marshal test.

4B.6.17.5 Preparation of Asphalt Mix

The materials for the asphaltic surfacing shall be mixed in an approved mechanical mixing plant. The aggregate shall be heated until dry at a temperature of 120 to 165^0C and the bitumen shall be heated

to 120° to 150° C. Thorough mixing shall be carried out to ensure that all particles of the aggregate are completely coated.

The different aggregates shall be stored separately and the mixing and weighing plants shall be maintained at all times in a clean and proper condition.

The asphalt mix shall be transported from the mixing plant to the laying area as quickly as possible, and in clean vehicles. The hot asphalt must be protected by tarpaulins or the likes against adverse weather conditions and if for any reason, including unavoidable delay, the temperature of the asphalt should become lower than 100° C or too low for satisfactory spreading than the whole load shall be rejected.

4B.6.17.6 Laying of Surfacing

Except where otherwise permitted by the Engineer, the asphalt shall be laid by an approved mechanical spreader handled by skilled and experienced operators, and the asphalt shall have a temperature between 100 and 150^0C at the time of laying. During the process of spreading the rate of travel of the spreader shall not be in excess of 4m. per minute. Compaction of the asphalt shall be carried out first with a 3 to 5 ton steel roller, then with an 8 to 10 ton smooth wheel roller. Roller shall commence when the temperature of the asphalt is still above 80 C, and shall be carried out in a longitudinal direction commencing at one edge of the area or road and working of the cross fall, and shall be carried out in successive passes with each rear wheel overlapping the preceding rear wheel track by one half. The rolls or wheels shall be kept moistened and the roller shall be capable of reversing without backlash and the points at which it reverses shall be staggered.

The finished surface of each course shall be tested with a 5m straight edge, and shall not show any depression in excess of 8 mm for the base course and 5mm for the wearing course except at drainage ditches and across the chamber. Unless otherwise indicated the cross fall of the finished road or yard shall be about 1 in 40 towards the drainage channel or ditch.

Around manhole and inspection covers and gully boxes or frames the surfacing material shall be neatly tamped so that after final compaction the finished, surface is left slightly poured of, but not exceeding 10mm above, such fittings and the surfacing shall be slightly sloped so that surface water will be directed to the gullies or channels. The asphalt shall be neatly dressed up to precast concrete kerbs and the like and the Contractor shall include in his prices for any interruption to works occasioned by such finishing operations.

4B.6.17.7 Tack Coat

If the period between laying the two courses of asphalt for any part of the works exceeds three days, then the surface of the base course, for that part shall be sprayed with a tack coat of hot bitumen at a temperature to be determined by the Engineer, after suitable tests have been carried out on the site under the Engineer's direction to determine the optimum temperature. The surface of the base course shall be cleaned of all loose and windblown sand or any other material or matter prior to the application of the tack coat, which shall be sprayed on immediately before to the laying of the wearing course.

Tack coats are also to be applied by brush to joints between concrete and wearing course and between steel fittings and the wearing course; and also at the commencement of the laying of a new section of wearing course, the end of the previous section is to be cut back to give a neat vertical face which shall be coated before the new material is laid against it.

4B.6.17.8 Opening to Traffic

The Engineer will decide when and if the base course may be opened to traffic. The asphalt wearing course may be open to light vehicular traffic 24 hours after completion of laying and to general traffic 3 days after completion of laying.

4B.6.17.9 Other Road Surfaces

Certain areas and sections of road may not be constructed in the standard method as detailed above. Such areas and sections are indicated on the drawing.

Areas to receive gravel surfacing are to be rolled and compacted as detailed above and provided with a wearing course of coarse gravel of 5 cm. thick. The voids are to be filled with fine sand and the layer fully compacted as before.

Roads subject to light traffic only may be required to be treated with out-back bitumen sprayed over the road base which is constructed as described above. The bitumen layer is then blinded with coarse sand and lightly rolled.

Details of any other surfaces required are shown on the Drawings.

4B.6.17.10 Paved Areas

Pedestrian access and other areas detailed on the Drawings or indicated by the Engineer shall be paved with 5 cm. thick precast concrete flags laid as specified or with reinforced concrete slabs with a tamped finish. The concrete flags shall be made in conformity with the details shown on the Drawings and in accordance with the requirements concerning precast concrete detailed in clause 4B.7.8 of this specification. Workmanship and laying of the flags and preparation of the bedding thereto shall be carried out in accordance with the requirements of the relevant Clauses of this specification or the latest British standards.

4B.6.17.11 Kerbing

Where required by the Particular Specification or shown on the Drawings, Kerbs shall be laid or built in the indicated positions and places. Kerbs should be of precast units as directed and shall be laid with regular drainage gaps as indicated.

Precast kerbs should be obtained from the National Industries Company in Kuwait and shall be made of a size 12.5 cm thick x 25 cm deep with one face half splayed. These kerbs shall be laid on a prepared foundation of concrete N25, 40cm. wide x 30cm. deep and backed with a triangular haunch section of the same mix. Where these kerbs are to be placed on excessive fill material the concrete foundation shall be increased in depth as directed by the Engineer. Kerbs shall be laid true

to line and level in all respects, and shall be pointed in cement and sand mortar (1:3 mix). Quadrants radius kerbs, drop kerbs and the like shall be purpose made in accordance with the Drawings.

All concrete work in connection with concrete kerbing whether with regard to materials or workmanship shall be executed complete in accordance with the requirements of chapter 4B.7 of this specifications.

4B.6.17.12 Service Ducts

Service Ducts, to carry power cables and other services under roads and paved areas and to serve the path and site lighting shall be laid in trenches 70 cm. deep. The ducts shall be of flexibly jointed concrete or PVC pipes as specified on the relevant drawings and those passing under roads shall be bedded on and surrounded with 15cm. of concrete N25. Where cables or wires are to be drawn into the ducts later, stainless steel or copper wires of suitable dimension are to be positioned in the ducts during laying for subsequent "pulling-in" of the power cables.

NOTE: The Construction of the internal roads to be according to the Ministry of Public Works Specifications and can be taken from the Ministry of Public Works at the Contractor's cost.

4B.7 REINFORCED CONCRETE:

4B.7.1 Standards

The following standards and codes in their latest editions shall apply to works covered by this chapter:

B.S.NO.

410	Test Sieves.
812	Methods for sampling and testing of mineral aggregates, sands and fillers.
882	Specification of aggregates from natural sources for concrete.
4483	Steel fabric for the reinforcement of concrete.
4466	Bending dimensions of bars for the reinforcement of concrete.
1881	Methods of testing concrete.
3148	Tests for water for making concrete.
8007	Code of practice for the structural use of concrete for retaining aqueous liquids.
4449	Specification for Hot Rolled Steel Bars for the Reinforcement of concrete.
8110	The structural use of concrete.
5212	Cold poured joint sealants for concrete pavements.

C.P. NO.

C.P. 102 Protection of buildings against water from the ground.

DIN NO.

1048 Regulations for testing concrete used during erection of concrete and reinforced concrete structures. (Water-tightness test).

ASTM NO.

C.150 Specification for Portland Cement.
C.332 Specification for lightweight aggregates for insulating concrete.
C.494 Chemical admixtures for concrete.
C.167 Corrosion-resisting chromium-nickel steel plate, sheet and strip.
A.167 Standard specification for stainless and heat resisting chromium.
D.1752 Preformed expansion joint fillers.
D.2125 Cellular polystyrene.

4B.7.2 Material and Workmanship

All materials used in the works shall be the best, of their kind and shall conform in quality and treatments to the conditions herein specified. The Contractor shall submit to the Engineer when required and at his own expense samples of all materials to be used in the works, the quality of the samples so provided being representative of the bulk of such materials.

The construction of all concrete and reinforced concrete work shall commence at points approved by the Engineer and shall be continued and completed in accordance with programs of works to be submitted to him for approval before work is commenced. The Contractor's attention is drawn in clauses 4B.7.7.3 and 4 hereunder. Any workmanship and therefore liable to be a point of weakness in any part of the works shall be demolished and rebuilt at the expense of the Contractor.

All construction shall be executed by competent workmen in accordance with the best modern practice and to the satisfaction of the Engineer.

Only competent foremen and first class concretors shall be employed and should the Engineer so request in writing, the Contractor shall immediately replace any foreman or concretor who is considered to be incompetent**.**

4B.7.3 Cement

4B.7.3.1 Manufacture and Supply

Sulphate resisting cement type V conforming in all respects to ASTM C150 shall be used for all concrete works of the Reservoirs, all valve chambers, Thrust blocks and all drainage manholes including floor slabs, walls, wall footings, columns, column footing, roof slabs, blinding concrete and all concrete work under ground level for all other structure etc.

Ordinary Portland cement type I comply with ASTM C150 shall be used only for all concrete works above ground level for other structure.

The cement shall either be delivered in sealed bags contain 50 Kg. net weight + 1 percent, marked with the manufacturer's name or in barrels or containers shall contain multiple thereof in a manner approved by the Engineer.

The sources of supply of cement shall be subject to the Engineer's approval and the Contractor shall at all times furnish the Manufacturer's test certificates and proof that the required standard specification has been complied with, together with a note of the data of manufacture certified by an independence agency in the country of origin. The Engineer shall have the power to reject a part or the whole of any consignment of cement if he considers it to be unsuitable for use in the works.

It is preferable to supply the cement from Kuwait Cement Factory.

4B.7.3.2 Delivery and Storage

Cement shall be delivered to the site in sealed bags or in watertight barrels bearing the Manufacturer's name & the date of manufacture.

The cement shall be stored in piles not more than eight bags high in perfectly dry waterproof sheds or other such temporary buildings approved by the Engineer, each having a floor area of not less than 50 square meters or greater if the Engineer considers it necessary.

These buildings shall be used exclusively for the storage of cement and shall be erected with the floors raised well above the ground, at places on or near the site of the works, and at the completion of the works the buildings shall remain the property of the Contractor and shall be dismantled and removed, the foundations broken up and the site restored to its original condition by him.

A free passage of at least one meter shall be left between the cement and the side walls of the sheds. Access ways shall also be left between the stored bags of cement such that every bag is visible. Each consignment of cement shall be stored apart from earlier consignments and consignments shall be used in the order in which they are delivered. Any consignment which has become caked or otherwise adversely affected shall be removed from the Site immediately.

The Contractor shall provide weighing machine which shall be kept permanently in each shed for checking the weight of the bags or barrels of cement. The Engineer shall have access at all times to the cement storage sheds. During transport and storage the cement shall be fully protected from the sun.

4B.7.4 Concrete Aggregates

4B.7.4.1 Availability of Aggregates in Kuwait

The sources, quantities available and properties of sand and coarse aggregates in Kuwait are fairly well-known due to the extensive developments of recent times. In general although sands are extremely plentiful throughout Kuwait, most are too fine, too badly graded and/or chemically impure for constructional use. Better graded sands are becoming more difficult to obtain, though there are sources available, for instance pockets of coarse sand may be found between Magwa and Jahra but careful selection at the pits to ensure satisfactory grading is required. Washing of sands is always required.

Gravel deposits in the area north of Mutla appear virtually inexhaustible. very large quantities of surface material have already been swept away for use, but there are still extensive beds within the zone bounded at the Basrah Road and Khor al Subiyah. The natural gravel is round in shape and the

grading inconsistent so crushing is necessary. Normal screed is nearly but washing of the stone is not generally required.

Other locally occurring materials can on occasion satisfy the requirement of the specification for concrete aggregate.

4B.7.4.2 Fine and Coarse Aggregates

In all cases, whether the Contractor wishes to make use of sources mentioned in the report or other sources, he shall at his own expense have the aggregates tested and submit the relevant reports together with representative samples to the Engineer. The Engineer shall carry out such further testing of the aggregates as he considers necessary before giving his approval and no aggregates may be used on the works until such approval has been given. All aggregators shall comply with the requirements of B.S.882 in all respects and shall be subject to the tests laid down in B.S.812.

For both the fine and coarse aggregates which he proposes using, the Contractor shall furnish the Engineer with the following information:

i. Source of supply, i.e. country, town and name of precise locality of quarry.

ii. Group classification, as determined according to BS.812, Clause 9(a).

iii. External characteristics i.e. shape and surface texture, as determined according to B.S.812, Clause 10.

iv. Physical properties as determined according to the Clauses of B.S.812 indicated, as follows:
- Absorption value and specific gravity clause 16 or 17 as appropriate.
- Bulk density – clause 19.
- Aggregate crushing value – clause 23 or 25 as appropriate.

v. Grading, i.e. a typical sieve analysis as determined according to B.S.812, Clause 11.

The above information must be certified as correct by the Contractor and by his proposed supplier in his case.

The representative samples shall then, at the Contractor's expense, be subject to exhaustive tests to prove their quality and suitability and to determine the proportions of fine to coarse aggregates appropriate to each class of concrete.

The Contractor shall make his own arrangements for crushing, screening, washing, supply, delivery and storage of all fine and coarse aggregates as may be required for concrete on the works.

Throughout the concreting operations, the Engineer will carry out frequent tests in accordance with B.S.812 to check the suitability of the aggregates. Should the tests reveal the aggregates to have unsuitable characteristics at any time the Engineer may order such aggregates to be rejected or their use to be discontinued.

4B.7.4.3 Grading of Aggregates

The grading of the fine and coarse aggregates shall be such that when they are mixed in the proportions decided for each class of concrete the grading of the combined aggregate shall be suitable for making a dense concrete of appropriate workability with the proportions of cement and water with which the aggregate is to be used.

1 - Fine Aggregate

Fine aggregate for concrete N20, N25 and N30 shall be well graded and as the sand in Kuwait is limited in size to a narrow range it is advisable to mix two sizes when tested by means of laboratory sieves the fine aggregate shall conform to the following requirement.

B.S.SIEVE (NO)	SIEVE OPENING (MM)	% PASSING (BY WEIGHT)
3/8"	9.51	100
3/16"	4.76	95-100
7	2.40	75-100
14	1.20	40-80
25	0.600	20-55
52	0.300	10-25
100	0.150	0-10

Unless otherwise approved, all fine aggregate for each separate structure or part thereof shall come from one pit. All fine aggregate shall be washed and shall contain not more than 3 percent of silt determined in accordance with the test given in BS.812, Method C, correlated as directed by the Engineer with Method B. Also the maximum amount of sulphates as SO_3 shall not exceed 1000 p.p.m. and the maximum amount of chlorides shall not exceed 300 p.p.m. for reinforced concrete.

2 - Coarse Aggregate

Coarse aggregates for concrete work shall be crushed using the hammering method and shear breaking will not be permitted. The quantity of flaky aggregate shall be limited as much as possible. After crushing the coarse aggregate shall be screened and graded, and when tested by means of laboratory sieves shall conform to the requirements of BS.882, table 1, for graded aggregate, Maximum aggregate, size shall be 1.1/2" for all parts of the structure.

3 - All-in Aggregate

The proportions of fine to coarse aggregate and the maximum size of coarse aggregate to be used in each class of concrete shall be approved by the Engineer.

The Contractor shall be responsible for mixing the aggregates in the proportions approved by the Engineer for each class of concrete and each section of the work. He shall submit samples of the graded material to the Engineer well in advance of commencing any concrete work, and also have test cubes for crushing and specimens for water tightness tests made from the re-graded aggregate and the cement which he intends to use. Concrete works must not commence until such samples and tests are to the Engineer's satisfaction.

4B.7.4.4 Storage of Aggregates

The various fractions of fine and coarse aggregates shall be stored separately and in such a manner as to avoid the inclusion of dirt and other foreign material in the concrete Aggregate shall be handled in such a way that segregation is avoided.

4B.7.4.5 Lightweight or Expanded Aggregates

Lightweight or expanded concrete aggregate shall be Vermiculite or other similar equal aggregate and shall conform to ASTM C332 and the Contractor shall submit representative samples to the Engineer for approval before any such lightweight aggregate is used in works.

4B.7.5 Water for Concrete Mixes and Curing

Detailed information on the Water supplies for the Works is given elsewhere, however, unless otherwise authorized in writing by the Engineer, only water from the potable supply system of Kuwait may be used for mixing concrete and other products containing, cement. Similarly, only potable water may be used for curing concrete and cement products during the first seventy two hours after pouring. Later, Fresh water, Brackish water or other water containing not more than 4000 p.p.m. dissolved solids of which not more than 1000 p.p.m. chlorides, may be used for curing. The water used must at all times comply with the requirements of BS.3148.

The water shall enter the mixers at as low temperature as possible. Every effort should be made to protect water pipes, and tanks from the sun, e.g. burying, shading, insulation or white painting mixing water for watertight concrete shall be cooled by mechanical refrigeration or by mixing it with crushed ice. The quantity of ice shall be to the approval of the Engineer; but as a guide, with 50 percent ice in the mixing water the temperature of the concrete would decrease by about $12^{o}C$. Conditions must be such that the ice is completely melted by the time mixing is completed.

4B.7.6 Concrete Mixes

4B.7.6.1 Classes

The various classes of concrete to be used in the Works shall conform to the following table:

TABLE – 1
CONCRETE CLASSES

Class of concrete	28 days cube strength		7 days cube strength	
	Prelim test N/MM^2	Work test N/MM^2	Prelim test N/MM^2	Work test N/MM^2
N 35	47	35	35	23.5
N 30	40	40	30	22
N 25	35	25	25	20
N 20	30	20	20	15
N 15	24	15	15	10

All concrete shall be watertight and shall utilize Type V cement, unless specified otherwise.

All concrete testing shall be carried out in accordance with BS.1881 and Clause 4B.7.12.4 hereunder.

The "Water-Cement ratio" and the maximum aggregate size shall be specified in the design of the concrete and the actual mix to be used in each case shall be approved by the Engineer. The mix proportions will be stated by weight, and the Contractor will be required to proportion the materials by weight at all times and must provide adequate plant for this purpose. The Engineer may from time to time as he considers necessary, amend the concrete MIX proportions to be used.

4B.7.6.2 Slumps

Recommended limitations for slump are given in Table 2 hereunder. The method of making the slump test shall conform to BS.1881.

Mixes of the stiffest consistency that can be placed efficiently should be used.

Over-wet mixes shall be rejected.

TABLE - 2
RECOMMENDED SLUMPS

Types of construction	Slump in cm
Plain un reinforced structures & reinforced heavy structures	2 - 5
Pavements	2 - 6
Reinforced slabs, beams, Walls, shells & columns.	4 - 8

4B.7.6.3 Water-Cement Ratio

The quantity of water used in mixing shall be approved by the Engineer on the basis of preliminary tests and trial mixes and shall be the least amount that will produce a workable homogeneous plastic mixture which can to work into the forms and around the reinforcement. In no circumstances shall be consistency of the concrete be such as to permit a separation of the aggregate from the mortar during handling. Excess water shall not be permitted and any batch containing such excess will be rejected, the maximum water cement ratio shall be not more than 0.5.

In measuring water for each batch of concrete, allowance shall be made for the water contained in the aggregates. The total water in the batch shall be deemed to consist of the water carried by the aggregates plus the water added.

Frequent tests including the slump test shall be carried out to ensure that consistent water content is maintained.

4B.7.6.4 Retarders and Admixtures

Setting time of concrete is very short during the normally prevalent hot seasons in Kuwait and "Cold joints" are often hard to avoid when large concreting works have to be carried out in one continuous operation. To avoid cold joints therefore, the Contractor shall have either to provide sufficiently large capacity in his concrete producing plant and concrete transporting arrangements or use an appropriate retarder. Should the Contractor elect to use a retarder then such retarder shall be of a type approved by the Engineer and shall conform to the requirements to Type D as specified in ASTM C494. The Contractor shall be entirely responsible for the use of any approved retarder in strict accordance with the Manufacturer's instructions. Retarder shall not be used together with other admixtures in the same mix unless approved by the manufactures.

Preliminary tests of cube strength and water tightness shall be carried out for all concrete with admixtures. When changing the brand or type of cement further tests shall be carried out.

The amount of and the place for the use of any admixture and the timing there of shall be as directed or agreed by the Engineer.

4B.7.6.5 Lightweight Concrete

This shall be mixed in the ratio of one bag (50 Kg) of cement to 8 cubic ft. (0.225 cubic meters) of vermiculite aggregate or equal conforming to ASTM C332.

The required strength of the insulating concrete shall be 10 Kg / cm^2. at 28 days and the oven dry density shall be 25-30 Lbs. /cubic ft. (400 - 480 Kgs/m^3). Trial mixes must be prepared for testing at least two months before the commencement of the actual casting.

The insulating concrete slabs shall be cast in squares not larger than 300 cm. x 300 cm in alternate bays, with a period lapse between adjacent bays of not less than 3 days. They shall be constantly and continuously cured similar to the curing of reinforced concrete. Great care shall be taken not to work over or place heavy objects on top of the slabs.

The lightweight concrete screed shall be covered while still green with a 1:4 cement / sand topping 10 mm thick finished level and smooth to the satisfaction of the Engineer.

4B.7.7 Mixing and Placing of Concrete

4B.7.7.1 Mechanical Mixing, Hatching

All concrete shall be machine mixed. The location of the batching and mixing plant shall be agreed with the Engineer and the Contractor must submit to the Engineer for approval before erection of any mixing plant his proposed arrangements for the storing of aggregates and the batching and mixing of the concrete. He must also submit details of the type or types of Mixers and machines to be used, and his proposals for conveying the mixed concrete from the mixer to the points of deposition.

All concrete shall be batched by weight and the weigh batching shall be of a type approved by the Engineer and shall be kept accurate and in good conditions while in use on the works. Checks are to be made as required by the Engineer to determine that the weighing devices are registering correctly. Each mixer shall be fitted with a water measuring device having accuracy within one percent (1%) of the

quantity of water required for the batch and the measuring device shall be such that its accuracy is not affected by variations in the water supply pressure.

If aggregate batching by volume is allowed, the cement shall be batched by weight and the water by weight or volume. Each size of aggregate shall be measured in a metallic container the depth of which is at least equal to its greatest width. The containers shall be of such shape that their volume can be easily checked by measurement.

The approved type of mixer should have a drum rotating about a horizontal or inclined axis and must be kept in good condition at all times. The drum shall rotate at the speed recommended by the manufacturer. Continuous mixers shall not be permitted.

Arrangements for the cooling of the mixing water shall be to the approval of the Engineer as well the handling of admixtures.

About 10 percent of the water required for the batch shall enter the drum in advance of the cement and aggregates, and the remainder of the water shall be added gradually while the drum is in action so that all the water is in the drum by the end of the first quarter of the mixing time. The concrete shall be mixed until a mixture of uniform color and consistency is obtained, and mixing should continue for at least 1.5 minutes after all the water has been added. Where double-drum high performance mixers of a type approved by the Engineer are used, a minimum mixing time of 70 seconds may be allowed.

The amount of concrete mixed in any one batch is not to exceed the rated capacity of the mixer. The whole of the batch is to be removed before materials for a fresh batch enter the drum. On cessation of work, including all stoppages exceeding 20 minutes, the mixers and all handling plant shall be washed with clean water. Any deposits of old concrete in the drum should be cleaned out by rotating clean aggregate and water in the drum before any fresh concrete is mixed.

Concrete mixed as specified above is not to be modified by the addition of water or in any other manner to facilitate handling or for any other reason.

4B.7.7.2 Placing and Compacting

Immediately after mixing, the concrete shall be transported to the place of final deposit by method which will prevent the separation, loss or contamination of any of the ingredients. Any method involving the use of pipes or chutes for transporting concrete will not be permitted, except with the written approval of the Engineer. Transport of concrete from the mixers must be as rapid as possible and the Contractor shall always be responsible for the concrete being placed and compacted within such a time from the addition of the water to the mixer that the previous lift of concrete has not commenced setting.

Before any concrete is poured, the formwork must be thoroughly cleaned of all dirt shavings loose stones etc., and the woodwork which will be in contact with the concrete shall be well soaked with water and/or treated with approved mould oil.

The concrete shall be placed gently in position and shall normally not have a face fall of more than one meter. To convey the concrete as near as possible to its final position, drop chutes of rubber or

metal shall be used for small sections and bottom dump buckets or other suitable vessels for large sections. The concrete shall be placed so as to prevent water from collecting at the ends, corners or along the faces of the forms, and it shall not be placed in large quantities at a given point and allowed to run or be worked over a long distance the form. All concrete shall be placed and compacted in even layers with each batch adjoining the previous one.

The thickness of the layers shall be between 15 and 30 cm. for reinforced concrete and up to 45 cm. for plain concrete the thickness depending on the width of forms, amount of reinforcement and the necessity of placing each layer before the previous one commence to set.

The concrete shall be carefully and continuously compacted and worked around the reinforcement and into the corners of the form work so that it will be in close contact with the reinforcement and free from honeycombing. Over-vibrations causing segregating shall be carefully avoided and the redistribution of concrete in the formwork by means of vibrators will not be permitted.

The concrete shall be compacted by mechanical or electromechanical vibrators of a type approved by the Engineer. The vibrators shall be of the plunger type for insertion in the concrete, except that external plate type vibrators shall be used if so required by the Engineer.

The plunger type vibrators shall have a diameter compatible with the spacing of the reinforcement, a sufficiently high frequency and shall be properly handled by experienced personnel. They shall be immersed at regular intervals close enough to vibrate all of the concrete but care shall be taken not to displace the reinforcement nor to disturb or affect any previously vibrated or partially set concrete. Each immersion shall continue until shortly after air bubbles cease to appear on the surface of the concrete, but shall not last more than 30 seconds. The vibrators shall be withdrawn gradually and vertically to ensure that no air pockets are formed.

When external vibrators are used they shall be clamped to the forms whenever possible to avoid undue impacts during handling and the forms shall be constructed to withstand the additional vibrations.

Vibrators shall not be attached to the reinforcement in any circumstances and vibrating shall not be carried out so that damage or disturbance is caused in adjoining sections of the work. Special care shall be taken to ensure that pre-stressing conduits and anchorages are not damaged. All conduits shall be inspected carefully immediately before concreting to check on positioning and any damage or potential leaks repaired, and just after concreting and before the concrete has set hard. The conduits shall be blown through with compressed air to ensure that there are no obstructions.

All vibration compaction and finishing operations shall be completed immediately after the placing of the concrete in its final position. Workers shall not be permitted to walk over freshly placed concrete until it has hardened sufficiently to carry their weight without distortion and great care shall be taken to ensure that reinforcement projecting from concrete recently placed is not taken or disturbed so as to destroy or damage the initial set of the concrete in contact with it.

Concreting in any one part or section of the work shall be carried out in one continuous operation and no interruption of concreting work will be allowed without the approval of the Engineer. The capacity of the mixing plant will therefore have to be sufficient to supply concrete continuously during these operations.

Where beams and slabs together form an integral part of the structure, they shall be poured in one operation, unless provision is made to form a construction joint.

4B.7.7.3 Weather Precautions

During hot weather, steps shall be taken to reduce the concrete temperature and rate of water evaporation by proper attention to the cooling of the mixing water before use, production methods and the handling and curing. The concrete mixing plant shall be screened and covered as a protection from wind, rain and sun and adequate similar precautions taken throughout the transit, placing and curing of the concrete whenever conditions require them.

When the shade air temperature is 35°C and rising special precautions must be taken during all concreting operations so that the temperature of the concrete when placed does not exceed 29°C. Shading of aggregates and plant is beneficial and the cooling of mixing water and other steps taken shall be to the approval of the Engineer. Fresh concrete placed at this temperature shall be shaded from the direct rays of the sun to the satisfaction of the Engineer.

Concrete is not to be mixed and placed when the shade air temperature is 40 ºc or above**.**

4B.7.7.4 Continuity of Concrete Works

The Contractor shall, at least three weeks before the desired to begin the concreting of any main part or section of the concrete works, submit to the Engineer for approval a program of works including procedure, any special arrangements and the methods by which he proposes to construct that part or section. The submission to and approval by the Engineer of the said program shall not relieve the Contractor of any of his duties and liabilities under the contract.

Whenever instructed by the Engineer, the Contractor shall carry out the work in such a manner that the placing of the concrete in any particular section of the structure shall be executed without any interruption whatsoever from the beginning to the end of the operation. When interruptions are permitted by the Engineer, no fresh concrete shall be deposited on or against the concrete place before the interruption until the latter is sufficiently set to resist injury.

Particular care shall be taken to ensure that partially set concrete shall not be damaged by shock or any other cause whatsoever.

Casting of concrete shall not commence until a sufficient quantity of approved material is at hand to ensure continuity of operation, nor shall work commence until there is sufficient equipment is reserve in case of breakdowns. Fully standby plant and equipment shall be provided including electricity generating equipment, cranes, elevators, mixers, vibrations, trucks, etc.

4B.7.7.5 Joints in Concrete Works

For definitions of the various types of joints, see BS.8007 code.

Joints shall, as a rule, be limited to the positions shown on the drawings and shall be of the type specified. No joints of any description shall be permitted other than those indicated on the drawings

without the prior consent of the Engineer, which consent shall only be given where there is a good reason for each joints to be included.

Contraction, construction joints, expansion and sliding joints are detailed on the drawings and shall be constructed in principle in accordance with the recommendations of BS. 8007. Movement joints in water retaining structures shall be so constructed as to maintain water tightness whilst accommodating relative movement between the sides of the joint, and suitable approved materials for this purpose shall conform to BS. 8007. Movement joints shall also incorporate in their construction adequate protection against the entry of debris or other material that may interfere with the closing of the joints**.**

4B.7.7.5.1 Water Stops

The water-stops shall be fabricated from a plastic compound the basic resin of which shall be Polyvinyl Chloride (PVC). The compound shall contain additional resins, plasticizers, inhibitors or other material such that when the material is compounded, it shall meet the requirements of this specification. No reclaimed P.V.C shall be used.

All water-stops shall be mould or extruded in such a manner that any cross section will be dense, homogenous and free from porosity and other imperfections. The water-stops shall be symmetrical in shape.

The required sizes and weights shall be as shown on plans.

Water stops shall conform to the following physical requirements of P.V.C compounds (BS.2571/63 Class I-A3).

i. Tensile Strength

Tensile strength shall not be less than 2000 Psi and the test shall be in accordance with BS.2782 Part 3: Methods 320A to 320F.

ii. Ultimate Elongation

The ultimate elongation shall be not less than 225% when tested in accordance with BS.2782-Part 3. (320 A).

iii. Tear Resistance

The tear resistance shall not be less than 250 lbs. per inch when tested in accordance with ASTM D-624-81 (Dia. B.O.).

iv. Low Temperature Brittleness.

The material shall not crack at (-25°C) when tested in accordance with ASTM D-746-55T.

v. Deformation Under Heat

Deformation under heat shall not exceed 55% when tested in accordance with BS.2782 Part 1: Method 122A.

The center line of the water-stop shall coincide with the center line of the joint opening.

All junctions in water stops shall be formed using factory made intersections, butt jointing only between similar sections shall be carried out on Site using the manufacturer's special jig and strictly in accordance with manufacturer's instruction. Contractor shall supply complete approved water stop layout drawings to the manufacturer.

All site butt welds shall be tested for water tightness by spark tests and approved by Engineers representative before use in the reservoir. Contractor's staff shall be properly trained by manufacturer's representative for butt welding and spark testing of water stop at site. Prices shall include for all splices and laps.

Water-stop, when fixed in position, shall be held firmly in their required places and to the true required straight line. Eye holes made in factory shall be provided in water stop where required, especially where the water stop is hanging in the middle of wall kickers and other places. The water stop shall be tied with wire or clips to reinforcement to keep it in proper place and shape during and after casting till concrete has set. No piercing of water stop shall be allowed for any purpose. The two sides of the water stops prior to a casting shall be cleaned free of dirt, loose material and dust (and if necessary washed). Great care must be exercised when casting concrete to avoid the bending or twisting of the water stop and to fill in all spaces under, over or around the water stop.

Cross section of water stops shall be such that it does not aid formation of honeycombs around it taking care that it is compatible with maximum size of coarse aggregate. Width of the water stops shall be not less than what is shown in Drawings/BOQ's but in no case be less than 230 mm., the thickness of water stop should be 6mm at the middle and 4mm at the edges. The height of anchors in water stops shall not be less than 18 mm. and water stop should have 4-6 anchors depending on its location. Position of water stops shall be according to the drawings and in conformation to B.S. 8007. The distance of water stop from the nearest exposed concrete face shall not be less than half the width of the water stop, type of water stops shall be approved by the Engineer.

Prior to ordering water stops, the Contractor shall submit to the Engineer's review sufficient data to show general compliance with the specification requirement.

Certificate test report from the water stop manufacturers on the actual batch of material being supplied, indicating compliance with the requirements shall be furnished to the Engineer before use.

Water stops shall be tested in accordance to the latest standards at the cost of Contractor, before and during manufacture at the independent laboratories, place of manufacture as designated by the Engineer for physical & chemical tests. The Contractor shall take into consideration the time factor regarding completion of tests.

Contractor will appoint Inspectors approved by MEW to test and inspect the material during manufacture at the place of manufacture. List of MEW approved Inspectors are available in the Ministry. Cost of inspection and testing payable to the Inspector would be paid by the Contractor. No material will be

shipped by the manufacturer without the release note of the inspectors; this should be mentioned in the Letter of Credit (L.C.).

4B.7.7.5.2 Joint Sealant - In Contact With Water

The sealant to be used in the joint shall be two part polyurethane sealant comprising a base compound and curing agent. The sealant shall be non-toxic which can be used in drinking water reservoirs capable to withstand service temperatures range from 10°C to 80°C submerged continuously in water. The application and placing shall be done strictly according to manufacturer's instructions.

Vertical joints sealant shall be gun grade or troweling grade, horizontal joint sealant shall be pouring grade both conforming to latest editions of Federal Specification TT-S-227e, USAS A116.1, ASTM C920 Type M, grade P or NS Class 25, ASTM-C-962, ISO 3447, BS 6920 & NSF 61. Joints width shall be designed according to BS 6093. All sealant size in expansion joints shall be 4 cm x 2 cm (4 cm wide, 2 cm depth).

The material used for forming joints shall be left in joints until just before the joints are to be prepared to take the sealant. After removing the forms from the joints, all laitance & fins shall be removed and the joints shall be absolutely cleaned as per manufacturer recommendations. The joints shall be allowed to become thoroughly dry, after which they shall be blown out, immediately thereafter, they shall be primed and filled with joint sealant. The primer used shall be from the same manufacturer supplying the sealant. No sealant will be permitted to be used without a primer. Care shall be taken to completely fill the sealant grooves. Areas designated to receive the sealant shall be thoroughly cleaned; prior to application of the sealant. Concrete shall be cured for a minimum period of 28 days and be completely dry at the time of application. Humidity in air shall be not more than 50% during application. To check humidity inside & outside the reservoir. Humidity meter shall be installed. Concrete and air temperature during the application of sealant shall be between 10°C to 38°C. No sealant shall be applied at higher or lower temperatures. Temperature of sealant shall not be below 15°C or above 30°C at the time of application. No sealant shall be applied during rain. Proper ventilation shall be provided to remove volatile organic solvents from inside the reservoir. Contractor shall provide minimum (but not limited to) 6 exhaust fans and 2 blowers per compartment during sealant application as per the requirement of site, catalog & satisfaction of the Engineer's representative at site.

Sealants shall be stored in air-conditioned storage at site, keeping storage temperature of 15°C to 27°C. All cans should have clearly printed batch Nos., date of manufacture, date of expiry (stickers shall not be accepted). All expired materials shall be removed from site and not allowed to be used. Care should be taken in case of expiry dates of activators (hardeners) which are generally six months or less. The sealant shall be polyurethane polymer designed for bonding concrete which is continuously submerged in water. No material will be acceptable which has an unsatisfactory history as to bond or durability when used in joints of hydraulic structures.

Repairs to broken edges of joints shall be done by approved epoxy mortar (non-toxic & water tight). (Ratio of epoxy to fine aggregate should be 1:4 or less)

A separating layer (bond breaker) between filler & sealant shall be used before applying primer.

Prior to ordering the sealant material, the Contractor shall submit to the Engineer's review, sufficient data to show general compliance with the specification requirements. The material shall meet the following requirements:

Work life (Pot life)	30-90 minutes
Time to reach 20 Shore "A" hardness (At 77°F, 200 gr. quantity)	24 hours, maximum
Ultimate Hardness	30-40 shore "A"
Tensile Strength	250 p.s.i., minimum
Ultimate Elongation	400%, minimum
Tear Resistance (Die C ASTM D624)	75 lbs/inch of thickness, minimum

In addition, the material shall show no signs of adhesive or cohesive failure when tested in accordance with the following procedure in laboratory and field tests:

1. (aa) Sealant specimen shall be prepared between 2 concrete blocks (1-inch by 2-inch by 3-inch). Spacing between the blocks shall be 1/2-inch. Coated spacers (2-inch by 1-1/2 inch by 1/2-inch) shall be used to ensure sealant cross-sections of 1/2-inch by 2-inches with a width of 1/2-inch.

   (bb) Sealant shall be cast and cured according to manufacturer's recommendations except that curing period shall not exceed 24 hours.

   (cc) Following curing period, the gap between blocks shall be widened to 1-1/4 inches. Spacers shall be used to maintain this gap for 24 hours prior to inspection for failure.

2. Certified test reports from the sealant manufacturer on the actual batch of material being supplied indicating compliance with the above requirements shall be furnished to the Engineer before the sealant is used on the job. The primer and sealant shall be placed strictly in accordance with the printed recommendations of the manufacturer taking special care to properly mix the sealant prior to application. All sealant shall cure at least 7 days before the structure is filled with water.

3. The sealant shall be installed by a competent waterproofing sub contractor who has a successful record of performance in similar installations. Before work is commenced, the crew doing the work shall be instructed as to the proper method of application by a representative of the sealant manufacturer. The Contractor shall provide a 5-year written guarantee of the entire sealant installation against faults and/or incompatible materials and workmanship, together with the statement that he agrees to repair or replace, to the satisfaction of the Owner at no additional cost to the Owner, any such defective areas which become evident within said 5-year guarantee period.

4. The Contractor shall prepare adhesion and cohesion test specimens per Sub-paragraph (1) at intervals of five working days while sealants are being installed.

Sealants shall be tested is accordance to the latest standards, at the cost of Contractor, before and during manufacture at the independent laboratories, place of manufacture as designated by the Engineer for physical, chemical. & toxicity tests. The Contractor shall take into consideration the time factor, regarding completion of tests.

Contractor will appoint Inspectors approved by MEW to test and inspect the material during manufacture at the place of manufacture. List of MEW approved Inspectors are available in the Ministry. Cost of inspection and testing payable to the Inspector would be paid by the Contractor. No material will be shipped by the manufacturer without the release note of the inspectors; this should be mentioned in the Letter of Credit (L.C.).

Testing of sealants

Following tests shall be done according to:

T T-S-227e & USAS A 116.1	-	All tests as specified.
ASTM-C510	-	Staining and color change.
ASTM-C603	-	Extrusion rate & application life.
ASTM-C639	-	Rheological (flow) properties.
ASTM-C661	-	Indentation and hardness by Durometer.
ASTM-C679	-	Tack free time.
ASTM-C711	-	Low temperature flexibility and tenacity.
ASTM -C718	-	Ultraviolet (UV) - Cold box exposure.
ASTM -C719	-	Adhesion and Cohesion.
ASTM –C792	-	Effects of heat aging on weight loss, cracking and chalking.
ASTM- C793	-	Accelerated weathering.
ASTM-C794	-	Adhesion in Peel.
ASTM-D412	-	Tensile strength & extension at break.
ASTM-D624 Die "C"	-	Tear strength.
ASTM-D2398	-	Softening point, ring & ball.
ASTM-D648	-	Brittleness temperature.
ASTM-D2240	-	Hardness shore "A"
ASTM-E96-Method E	-	Permeability of water vapour.
ASTM-C501	-	Abrasion Resistance - net loss mg.
BS6920	-	Organoleptic & physical tests, toxic metal tests, cytotoxity tests, microbial tests. (toxicity tests).
NSF61	-	Toxicity tests as per (National Sanitary foundation Standard NO.61)

4B.7.7.5.3 Joint Sealant - Not In Contact With Water

The sealant to be used in the joint shall be two part polysulphide sealant comprising a base compound and curing agent. The sealant shall be capable to withstand service temperatures range from 10°C to 80°C. The application and placing shall be done strictly according to manufacturer's instructions.

Vertical joints sealant shall be gun grade or trowelling grade, horizontal joint sealant shall be pouring grade both conforming to latest editions of Federal Specification T T-S-227e, USAS A 116.1, ASTM C920 Type M, grade P or NS Class 25, ASTM-C-962, ISO 3447. Joints width shall be designed according to BS 6093. All sealant size in expansion joints shall be either 2 cm x 2 cm or 4 cm x 2 cm as shown on the drawings.

The material used for forming joints shall be left in joints until just before the joints are to be prepared to take the sealant. After removing the forms from the joints, all laitance & fins shall be removed and the joints shall be absolutely cleaned as per manufacturer recommendations. The joints shall be allowed to become thoroughly dry, after which they shall be blown out, immediately thereafter, they shall be primed and filled with joint sealant. The primer used shall be from the same manufacturer supplying the sealant. No sealant will be permitted to be used without a primer. Care shall be taken to completely fill the sealant grooves. Areas designated to receive the sealant shall be thoroughly cleaned; prior to application of the sealant. Concrete shall be cured for a minimum period of 28 days and be completely dry at the time of application. Humidity in air shall be not more than 50% during application. To check humidity inside & outside the reservoir, humidity meter shall be installed. Concrete and air temperature during application of sealant shall be between 10°C to 38°C. No sealant shall be applied at higher or lower temperatures. Temperature of sealant shall not be below 15°C or above 30°C at the time of application. No sealant shall be applied during rain.

Sealants shall be stored in air-conditioned storage at site, keeping storage temperature of 15°C to 27°C. All cans should have clearly printed batch Nos., date of manufacture, date of expiry (stickers shall not be accepted). All expired materials shall be removed from site and not allowed to be used. Care should be taken in case of expiry dates of activation (hardeners) which are generally six months or less. The sealant shall be polysulphide polymer designed for bonding concrete which is continuously submerged in water. No material will be acceptable which has an unsatisfactory history as to bond or durability when used in joints of hydraulic structures.

Repairs to broken edges of joints shall be done by approved epoxy mortar (non-toxic & water tight). (Ratio of epoxy to fine aggregate should be 1:4 or less).

A separating layer (bond breaker) between filler & sealant shall be used before applying primer.
Prior to ordering the sealant material, the Contractor shall submit to the Engineer's review, sufficient data to show general compliance with the specification requirements. The material shall meet the following requirements:

- Work life (Pot life) - 45-90 minutes
- Time to reach 20 Shore "A" hardness (At 77°F, 200 gr. quantity) - 24 hours, maximum
- Ultimate Hardness - 30-40 shore "A"
- Tensile Strength - 250 p.s.i., minimum
- Ultimate Elongation - 400%, minimum
- Tear Resistance (Die C ASTM D624) - 75lbs/inch of thickness, minimum
- Color - Light grey

In addition, the material shall show no signs of adhesive or cohesive failure when tested in accordance with the following procedure in laboratory and field tests:

1. (aa) Sealant specimen shall be prepared between 2 concrete blocks (1-inch by 2-inch by 3-inch). Spacing between the blocks shall be 1/2-inch. Coated spacers (2 inch by 1-1/2 inch by 1/2-inch) shall be used to ensure sealant cross-sections of 1/2-inch by 2-inches with a width of 1/2-inch.

   (bb) Sealant shall be cast and cured according to manufacturer's recommendations except that curing period shall not exceed 24 hours.

   (cc) Following curing period, the gap between blocks shall be widened to 1-1/4 inches. Spacers shall be used to maintain this gap for 24 hours prior to inspection for failure.

2. Certified test reports from the sealant manufacturer on the actual batch of material being supplied indicating compliance with the above requirements shall be furnished to the Engineer before the sealant is used on the job. The primer and sealant shall be placed strictly in accordance with the printed recommendations of the manufacturer, taking special care to properly mix the sealant prior to application. All sealant shall cure at least 7 days before the structure is filled with water.

3. The sealant shall be installed by a competent waterproofing sub Contractor who has a successful record of performance in similar installations. Before work is commenced, the crew doing the work shall be instructed as to the proper method of application by a representative of the sealant manufacturer. The Contractor shall provide a 5-year written guarantee of the entire sealant installation against faults and/or incompatible materials and workmanship, together with the statement that he agrees to repair or replace, to the satisfaction of the Owner at no additional cost to the Owner, any such defective areas which become evident within said 5-year guarantee period.

4. The Contractor shall prepare adhesion and cohesion test specimens per Sub-paragraph (1) at intervals of five working days while sealants are being installed.

Sealants shall be tested is accordance to the latest standards, at the cost of Contractor, before and during manufacture at the independent laboratories, place of manufacture as designated by the Engineer for physical, chemical & toxicity tests. The Contractor shall take into consideration the time factor, regarding completion of tests.

Contractor will appoint Inspectors approved by MEW to test and inspect the material during manufacture at the place of manufacture. List of MEW approved Inspectors are available in the Ministry. Cost of inspection and testing payable to the Inspector would be paid by the Contractor. No material will be shipped by the manufacturer without the release note of the inspectors; this should be mentioned in the Letter of Credit (L.C.).

Testing of Sealants

Following tests shall be done according to:

T T-S-227e & USAS A 116.1-		All tests as specified.
ASTM-C510	-	Staining and color change.

ASTM-C603	-	Extrusion rate & application life.
ASTM-C639	-	Rheological (flow) properties.
ASTM-C661	-	Indentation and hardness by Durometer.
ASTM-C679	-	Tack free time.
ASTM-C711	-	Low temperature flexibility and tenacity.
ASTM -C718	-	Ultraviolet (UV) - Cold box exposure.
ASTM -C719	-	Adhesion and Cohesion.
ASTM –C792	-	Effects of heat aging on weight loss, cracking and chalking.
ASTM- C793	-	Accelerated weathering.
ASTM-C794	-	Adhesion in Peel.
ASTM-D412	-	Tensile strength & extension at break.
ASTM-D624 Die "C"	-	Tear strength.
ASTM-D2398	-	Softening point, ring & ball.
ASTM-D648	-	Brittleness temperature.
ASTM-D2240	-	Hardness shore "A"
ASTM-E96-Method E	-	Permeability of water vapour.
ASTM-C501	-	Abrasion Resistance - net loss mg.

4B.7.7.5.4 Expansion Joint Filler

The expansion joint filler shall be sponge rubber complying with the requirements mentioned in Clause 4B.7.16, Page No. 76.

4B.7.7.6 Concrete Blinding

Where any footing or other concrete work is to be constructed below ground level, the surface of the excavation shall be covered with a layer of 100 mm thick blinding concrete (N.25). In no case shall the thickness of the blinding concrete be less than the indicated on the relevant drawings.

The surface of the blinding for the ground reservoirs shall be covered by two layers of polyethylene sheets 0.3 mm thick for each and shall comply with the requirements of the Engineer, or as mentioned on the drawings.

4B.7.8 Precast Concrete

4B.7.8.1 Requirements

Precast concrete is to be as dense and to reach the same strength as concrete N30 but the grading and proportion of the material may be varied subject to samples being submitted to be approved by the Engineer. All clauses referring to cast in situ concrete shall apply to precast concrete and in addition, the Contractor shall satisfy the Engineer that the precast concrete units are not moved or loaded until they have attained the requisite strength.

4B.7.8.2 Transport, Storage and Erection

Units shall be so stored, transported and fixed that they will not be overstressed at any time or suffer any damage.

Precast units shall be adequately braced and supported during erection to ensure proper alignment and, safety.

4B.7.8.3 Finish

On removal from the moulds, the precast concrete units shall be examined and all surfaces that will be permanently visible shall have a smooth and dense finish of uniform texture free from holes, fins and shutter staining.

4B.7.9 Steel for Reinforced Concrete

4B.7.9.1 Steel Quality and Supply

Steel reinforcement shall be High tensile smooth round bars complying with BS 4449, BS 18 part (2) and BS 4482 or similar approved standard. Hot Rolled high yielding deformed bars with ASTM 615 Grade 60 with min. yield strength of fy= 4200 Kg/cm^2.

Representative samples of all steel reinforcement that the Contractor proposes to use in the works must be submitted before work is commenced to the Engineer for his written approval together with manufacturer's certificates stating clearly for each sample the place of manufacture, expected date and size of deliveries to site, and all relevant details of composition, manufacture, strengths and other qualities of the steel.

Should a steel sample under test fail to meet the specification requirements at any time and the Engineer considers that samples which were not truly representative were presented to him for test, or if it becomes apparent that steel reinforcement which has not been approved has been used on the works, then the Engineer may instruct the Contractor to break out and remove completely all such sections of the work already constructed using such suspect reinforcement.

All testing of steel reinforcement bars shall be carried out in accordance with B.S.4449.

4B.7.9.2 Bending and Anchorage

Bending schedules will be drawn up as applicable in accordance with BS.4466 and each reinforcement bar shall be bend to the exact dimensions specified in the relevant schedule.

Generally, deformed bars of steel reinforcement conforming to B.S.4449 needs no hooks and shall be bent to an inner radius or not less than ten times the diameter of the bar. Nevertheless, the recommendations of the manufacturer should be adhered to in each case. All bars shall be bent cold. Bars also shall not be welded except as called for in Clause 4B.7.9.5 hereunder unless the Engineer gives his approval in which case the welding shall conform to BS.5153.

No splices shall be made in the reinforcement except where shown on the drawings or approved by the Engineer, and all splices or overlaps shall comply entirely with the requirements of C.P.114, clause 310.

4B.7.9.3 Fixing of Reinforcement

The steel reinforcement shall be assembled to the exact shapes and dimensions as shown on the drawings. The rods shall be of the across sectional areas indicated and shall be fixed rigidly and accurately in the moulds in the positions shown on the drawings. The rods to ensure that the reinforcement framework as a whole will retain its shape and the framework shall be so temporarily supported as to retain its correct position in the moulds during the process of depositing and consolidating the concrete. The ends of all tying wires shall be turned into the main body of the concrete and not allowed to project towards the surface. Spacing blocks shall be used to ensure accurate cover to the reinforcement where necessary, and these blocks shall be of precast concrete of strength at least equal to that of the concrete being placed. They shall be as small as practicable and shall be securely fixed in position by means of wires cast into them. They shall be soaked with water immediately prior to concreting in**.**

No temporary supports to the reinforcement will be allowed to be incorporated in the finished concrete and metal clips or supports shall not be placed in contact with forms for exposed surfaces.

At the time of concreting, all reinforcement shall have been thoroughly cleaned and free from all loose rust, scale, mud, oil or any other coating that might destroy or reduce the bond, and it shall also have been cleaned of all set or partially set concrete which may have been deposited thereon during the placing of a previous lift of concrete.

4B.7.9.4 Cover, Bar Sizes and Spacing

The cover to reinforcement, general limits on bar sizes and spacing of bars shall comply with the requirements of C.P.114 or BS 8007 as applicable and shall be at least 40 mm for internal water retaining and external faces.

4B.7.9.5 Lightning Protection

Due to low frequency of storms accompanied by lightning and the probably poor earthing conditions, protection against lighting will be on the Faraday cage principle. Therefore, all steel work external railings, lamps standard fixings, steel staircases and ladders shall be connected to the reinforcement in the structure. Provision shall also be made for connecting pipes to the reinforcement where they pass through the structure.

Steel for Reinforced Concrete

Weights and dimensions of bars shall be as per specification (B.S. 4449), but for the diameters which are not mentioned in this specification, the requirements in the following table shall be fulfilled:

Diameters	Cross Sectional Area mm²	Weight Kg/M	Tolerance in weight	
			For group of Bars	For single Bar
14	153.93	1.208	± 2.5%	± 4.5%
18	254.45	2.000	± 2.5%	± 4.5%

22 28	380.13 615.75	2.983 4.837	± 2.5% ± 2.5%	± 4.5% ± 4.5%

4B.7.10 Form work

4B.7.10.1 Design

All formwork shall be designed and detailed by the Contractor. If retarding admixtures are to be employed, their effect should be duly considered during the calculation of the lateral pressures of the fresh concrete. Besides the weight of the formwork and freshly placed concrete, the design loads shall include the weight of workmen, equipment, runaways and impact.

When prefabricated formwork, shoring or scaffolding units are used, manufacturer's recommendations for allowable loads may be followed if supported by test reports or successful experience records. For materials which will experience substantial re-use reduced values may be required.

For temporary forms with limited re-use allowable stresses should be those specified in the appropriate design codes or specifications for temporary structures or for temporary loads on permanent structures. Where there will be a considerable number of form re-use, it is recommended that the formwork be designed as a permanent structure carrying permanent loads.

The design of the formwork shall be the sole responsibility of the Contractor and the strutting and bracing of the formwork shall be such that there shall be no harmful deformation of the forms under the weight of the plastic concrete or due to methods adopted for the placing and compacting thereof or due to any incidental loading. No appliance for supporting the formwork or staging shall be built into the permanent structure except with the Engineer's approval**.**

4B.7.10.2 Types

All formwork shall be fabricated in accordance with one or other of the types specified hereunder.

1. **Wrought Formwork**

   The surface shall be tooled or wrought and the formwork shall be constructed of steel or plywood or planed and dressed timber or undressed timber lined with an approved fiberboard. Plywood shall have a thickness of not less than 12 mm. and water-proof glue shall have been used in its fabrication.

2. **Lined Formwork**

   Formwork shall be of timber as sawn tongue-and-grooved timber boards, each of the same thickness and width.

3. **Sawn Formwork**

Formwork shall be of timber as sawn at the mill. Boards shall be of the same width**.**

All timber used in the formwork shall be sound well-sealed and free from loose knots, and all formwork shall be constructed so that all joints fit tight enough to prevent the leakage of grout. Wrought formwork shall have a completely smooth face with tight joints. In all formwork the pattern of the shutter joints shall be to the approval of the Engineer**.**

4B.7.10.3 Construction

The formwork shall be constructed accurately to represent the shape of the concrete as detailed on the drawings. It shall be of suitable design and substantial construction and be approved by the Engineer. The Contractor shall make any necessary adjustments to allow for shrinkage, settlement or deflection which may occur during construction so that the finished concrete sections conform accurately to the specified dimensions true to line level and camber.

Should the Contractor elect to use metal forms, they should preferably be of a type which does not require the use of wire or other ties that remain embedded in the concrete after the forms have been removed. Where ties are necessary bolts and rods should be used, but they must be arranged so that when the forms are removed, no metal shall be within 4 cm. of any surface. Bolts and rods through concrete structures which will be exposed to unilateral water pressure shall have 100 mm diameter washers of 2 mm steel plate welded to them in such a way as to prevent leakage along the bolt or rod.

Where holes are boxed out in the concrete for the subsequent building.in of pipes, brackets, rag-bolts or other ironwork and shall be accurately set out and securely fixed. Should the Contractor elect to use other methods for building-in the above-mentioned ironwork and things, such methods shall be used only with the Engineer's prior approval but such approval shall in no way relieve the Contractor of his responsibility for the accuracy of the final finished positions of such ironwork and things to be built in.

Openings for the inspection of the inside of the formwork and for the escape of water used for washing out shall be formed so that they can be conveniently closed before placing of the concrete. External and internal concrete corners shall in all cases be formed with 25 mm chamfers and splays unless the drawings are specific as to their omission. Pockets for holding down bolts shall be formed with expanded metal unless directed otherwise. The Contractor shall provide specially made forms for use as sides to joints.

4B.7.10.4 Embedded Articles, Pipes, etc.

All pipes passing through water retaining structures shall if possible be fixed in position before concreting. Boxing out for pipes shall, where required, be provided with an adequate water stop. Bolts, brackets and all other articles fixed in the concrete are to be built in as far as possible as the work proceeds. Where this is impracticable the pockets or mortices shall be of ample size and shape to allow the fittings to be properly cemented in and a water joint secured.

Special care shall be taken to ensure that the articles shall be securely fixed in the correct position and the Contractor shall be at his expense provide all necessary templates, temporary supports and other plant and labor required. Where necessary in order to comply with this clause, pipe work,

steel work, etc., shall be assembled before fixing and the whole assembly temporarily supported with adequate supports.

4B.7.10.5 Removal of Formwork

The Engineer shall be informed in advance when the Contractor intends to strike any formwork and through the formwork rests with the Contractor; the Engineer has, however, the right to fix the time of striking if he decides this to be beneficial to the work.

In the absence of particular requirements for special structures or conditions to be laid down from time to time by the Engineer the minimum period of time that must elapse between the pouring of the concrete and the slackening or striking of the formwork shall be as follows:

- Columns - 2 Days
- Beam sides - 2 Days
- Walls - 4 Days
- Soffits of beams (Props left in) - 8 Days
- Soffits of slabs (Props left in) - 7 Days
- Removal of props slabs - 14 Days
- Removal of props to beams - 21 Days

The time above are given as a guide only and may be increased by the Engineer if he considers it necessary.

The removal of formwork shall in all cases be supervised by an experienced foreman. All formwork shall be removed without such shock or vibration as would damage the concrete, and before the soffit formwork and props are removed. The concrete surface should be exposed, where necessary, in order to ascertain that the concrete has hardened sufficiently.

Any work showing signs of damage through premature loading is to be removed and entirely reconstructed at the Contractor's expense.

4B.7.11 Concrete Finishing Works

4B.7.11.1 Surface Finish

Unless otherwise shown on the drawings, all permanently visible concrete surfaces shall have a regular dense finish of uniform texture free from holes, fins and shutters staining. All arises shall be clean and true and great care shall be taken to ensure that all surfaces which will be in contact with water or any other liquid shall be particularly dense and smooth. Floors shall be evenly dusted with dry cement which shall be worked in with a steel trowel on the initial set of the concrete to form a hard smooth surface.

All surfaces of concrete cast against wrought shuttering shall be smooth and dense and immediately after the removal of the formwork all minor blemishes shall be removed. All projecting fins or other rough sections shall be rubbed down flush with carborundum stone, or other approved means

and the resulting grit and dust thoroughly washing off with clean water. Then as a separate operation a mixture of port land cement and sand, 1 to 1.1/2, shall be worked into the pores over the whole surface with a fine carborundum float in such a manner that no more material is left on the concrete face than is required to completely fill the pores, so that a uniformly smooth and dense surface finally presented.

All surfaces cast against lined shuttering shall have any fins of concrete removed but otherwise shall remain untouched. Bolt holes etc. shall be carefully filled to match the surrounding concrete.

Should any section of the concrete present a rough uneven honey-combed discolored or imperfect appearance when the shutters are removed, it shall be picked out to such a depth and refilled and properly refaced with such class of concrete as the Engineer may direct. Any pinholes shall be stopped up but in the event of excessive porosity being discovered the defective area shall be cut out and made good as specified above all at the Contractor's expense. No plastering up of such areas will be permitted.

Horizontal surfaces which will not be finished against formwork shall be brought to an even surface by means of screeds and tampers and shall be given a smooth finish by the use of floats at the time of placing.

Surfaces of floors and bases shall be wood-float or steel trowel finished and all doors shall be provided with a steel scaling strip and the whole concrete shall be steel-troweled.

All other special surface finishes to concrete work as may be indicated on the Drawings or instructed by the Engineer shall be executed in strict accordance with the relative specification or British Standard and to the satisfaction of the Engineer.

4B.7.11.2 Water Tightness of Finished Structures

All water including or containing structures shall be watertight and this shall be achieved by the production of a well compacted dense concrete, if possible without the use of waterproofing agents. The Contractor shall be responsible for the water tightness of the concrete and all water containing shall provide all labor, water drain, stoppers and other needful appliances for conducting the tests. All water containing structures shall be tested before the placing of the backfill, banking, etc. Any leak shall be stopped and the structure retested without additional cost to the Employer.

Testing of water tightness shall be carried out in the manner prescribed in BS.8007 briefly that the external faces of fully filled structures shall show no signs of leakage over a 7-day period after allowing a stabilization period of 7 days for absorption and autogenous healing.

The depth of water should be recorded and the water allowed to stand for a period of 7 days during which the total permissible drop after allowing for evaporation should not exceed 1/500 of the average water depth of the full tank or 10 mm whichever is the lesser.

The Contractor will be responsible for the water supply (to be taken from the nearest existing main pipeline). The method of transporting the water to site and all costs and charges in connection herewith shall be the responsibility of the Contractor who shall make his own arrangements therefore and the Ministry will accept no responsibility in this respect. All plant and equipment

including pumps, hoses, valves and the like and the water required to carry out all testing both for hydrostatic tests and for pressure testing shall be provided by the Contractor who shall also pay all costs in connection therewith.

4B.7.11.3 Testing of Roofs

The roofs of liquid-retaining structures should be watertight and should, where practicable, be tested on completion by flooding the roof with water to a minimum depth of 25mm for 24 hours or longer if so specified. Where it is impracticable, because of roof falls or otherwise, to contain a 25mm depth of water, the roof should have water applied by a continuous hose or sprinkler system to provide a sheet flow of water over the entire area of the roof for not less than 6 hours. In either case the roof should be considered satisfactory if no leaks or damp patches show on the soffit. Should the structure not satisfy either of these tests, then after the completion of the remedial work it should be retested in accordance with this clause. The roof insulation and covering should be completed as soon as possible after satisfactory testing.

4B.7.11.4 Fixing of Ironwork

All brackets, rag-bolts and other ironwork for which holes have been boxed out or left in the concrete of a structure shall be carefully grouted into their correct positions. The grouting shall be carried out with cement and sand ground in such a manner that there shall be no apparent difference in the texture or color throughout the face of the finished structure and that there shall be no seepage of water either between the ironwork and the set grout or between the set grout and the surrounding structure.

Grouting of bedplates for pipe work and valves etc. shall be carried out in a manner approved by the Engineer. Cement mortar for grouting and bedding shall be 1 to 3 Portland Cement and sand mixed to a suitable fluidity**.**

4B.7.11.5 Screed and Rendering

Surfaces which are required to receive a finishing coat of cement rendering or fine concrete Screed shall be thoroughly prepared and cleaned before work is commenced. On recently placed concrete the surface shall be backed and wire-brushed and roughened and all laitance removed to expose the aggregate. Should the concrete be already well hardened the surface shall be chipped sand-blasted to expose the aggregate.

All loose particles shall be thoroughly rinsed off with clean water and the rendering/or Screed placed as soon as the surface has been thoroughly wetted.

The cement mortar for rendering or screed shall consist of sand and cement mixed in an approved mechanical mixer and in the proportions 1:4 or as directed by the Engineer. The mortar shall be used immediately after mixing and any mortar has stiffened or commenced to set shall not be used. The sand shall be well graded and to the satisfaction of the Engineer.

Sand for concrete floor finishes shall conform to BS.882.

All rendering shall be finished to an even or polished surface with a float trowel or other suitable tool, special care being taken to obtain perfectly smooth and glazed faces. It shall be 2 cm in thickness when finished unless otherwise directed. The thickness of floor screed shall be as indicated on the drawings.

All rendering or screed must be protected from the elements and properly cured as described in Clause 4B.7.11.5 below. It must be kept damp especially during the setting period. Any cracks or parts which sound hollow when tapped or other defects in the rendering shall be cut out and re-rendered by the Contractor at his own expense.

4B.7.11.6 Curing

Freshly placed concrete shall be adequately protected from rain dust, storms, chemical attack, and the harmful effect of sun heat, wind, flowing water, vibrations and shocks. It shall also be fenced off or otherwise protected to prevent persons from walking thereon or articles being placed or thrown thereon. This protection shall continue until the concrete is sufficiently set such that it can no longer be damaged by these factors. The Engineer shall determine when the protection is no longer required but in any case this shall be not less than 24 hours after the time of placing.

Timber formwork covering the concrete shall be moistened with water at frequent intervals to keep it from drying during the curing period. Metal formwork exposed to the sun must be shaded from its direct rays, painted white or otherwise protected during the curing period.

All concrete shall be cured by being kept continuous moist for a period of at least 7 days after casting though in certain cases the Engineer may direct this period to be increased or allow it to be reduced. The curing shall be effected by covering all concrete surfaces with hessian or a layer of sand which is to be continuously watered to keep it damp by means of automatic sprinklers.

Curing compounds shall not be permitted for water retaining structures. Particular attention should be paid to having all facilities ready for prompt commencement of curing. Reliance should not be placed on the protection afforded by formwork, to which water should be applied as stated above while the forms are still in place. Water for curing can be obtained at the standard rate at the nearest water point and any pumping or pipe laying that may be required shall be done by the Contractor at his own expense.

4B.7.12 Testing

4B.7.12.1 General

Preliminary and works test of concrete and concrete materials including reinforcement steel shall be carried out at times stated in this specification or when directed by the Engineer.

As soon as the Contract is signed, such preliminary tests shall be carried out in order to avoid delays in determining any adjustments of aggregate cement mixes or additives that may be indicated by the tests.

In accordance with the requirements of Clause 4B.3.6 of this specification the Contractor shall before the commencement of work provide one field laboratory at the construction site and equip

with the testing apparatus listed hereunder for the testing of concrete work and materials; and the Contractor shall maintain such laboratories and equipment in every respect throughout the duration of the Contract to the satisfaction of the Engineer.

The Site Laboratory shall be equipped as follows:

i. Twenty-seven 6" cube moulds (Bs.1881).
ii. Twelve flexural beam moulds (CP.114, Clause 601).
iii. Six moulds for water tightness test samples (see Clause 4B.7.11.2 above)
iv. Water basins large enough for storage of specimens until they are transported to the central laboratory. Equipment to maintain the water temperature cooler less than 21^0 C.
v. Supply of transporting containers for specimens to keep the specimens damp transport to the central laboratory.
vi. Two, 12-oz. clear-glass graduated prescription bottles and supply of caustic soda for testing for organic impurities (BS.812).
vii. Three slump cones and three tamping rods (BS.1881).
viii. One electrical sieve analyzer and a set of 12" dia. B.S. test sieve (BS.410).
ix. One balance, including a set of weights, with accuracy of 1 g.
x. Three thermometers.

A central laboratory is to be provided and all testing of materials shall be carried out either at this laboratory or at the Government Testing and Laboratories Station, whichever the Engineer may direct. It shall be the Contractor's responsibility to make all arrangements for, and pay all costs of any description in connection with transportation of the test specimens and all other samples and test pieces required for testing to the central laboratory or the Government Station as required.

Testing for water tightness of finished structures shall be done in accordance with Clause 4B.7.11.2 of this Specification.

4B.7.12.2 Cement

In addition to the Manufacturer's Certificate referred to in Clause 4B.7.3.1, which must be furnished when the cement is supplied, all cement shall further be inspected in Kuwait and samples taken and tested, such that results are known immediately prior to its use on site.

Testing shall be carried out in accordance with the methods required by ASTM C 150.

4B.7.12.3 Aggregates

Sampling and testing of aggregates shall be as required by BS.882 and 1201 and in accordance with BS.812 'Method for sampling and Testing of Mineral Aggregates. Sands and Fillers. All sampling shall be done by or under the supervision of the Engineer; and tests shall be carried out to determine both the physical and chemical properties of the aggregates as well sieve analyses. As washing of the sand is specified, checking of the water content immediately before use is important.

4B.7.12.4 Concrete

All testing shall be carried out in accordance with the requirements of C.P.114, Clause 601 and B.S.1881, Method of Testing Concrete and the tests detailed below shall be made before and curing the execution of the works at the times indicated, Concrete with admixtures shall be tested separately.
Preliminary Tests on each kind of concrete to an appropriate mix shall include the following testing operations:

- Slump tests or compacting.
- Analyses of freshly mixed concrete.
- Determination of unit weight of freshly mixed concrete.
- Test for the compressive strength of moulded cubes.
- Test for water tightness according to DIN 1048. whenever required.

No type or grade of concrete shall be used in the works before the preliminary tests on that particular type of grade have shown that the compressive strength, workability and, when required, water tightness are satisfactory for the purpose for which the concrete is to be used.

Work Tests

Shall be made on concrete samples during the progress of the works.

1. Works Cube Tests

Should be made as specified in CP.114, Clause -601 C for each new grade of concrete or from each 100 cu.m. of concrete when the same grade is being used continuously , or as directed by the Engineer.

Nine (9) Test cubes (6") should be taken at each time and each should be marked with the date, the section of the work from which it was taken and any other information required, and dispatched to the approved laboratory for testing for compressive strength. 3 cubes shall be tested after 7 days and 3 cubes after 28 days and their average strength must not fall below the minimum strength specified for each type of concrete, and the lowest test result shall not be more than 20 percent below the average for the 3 cubes. The remaining 3 cubes shall be kept as spares, and after the 28 days curing period shall be stored in a shaded room. If they are not required for testing, the Engineer may agree to their disposal.

When the result of the 7-days test is unsatisfactory, the Contractor may elect to remove and replace the defective concrete without waiting for the 28-days test. If the result of the 28-days test is un-satisfactory, all concreting shall be stopped at the Contractor's expense and shall not proceed further without the written permission of the Engineer. The Contractor shall then, in accordance with the instructions of the Engineer, conduct tests of the concrete in the suspect portions of the structures in such manner as may be appropriate to the particular conditions or parts of the work. The concrete may be test loaded in site or cylindrical test cores may be drilled out and tested in accordance with BS.1881, Part 15. Should the tests prove that the concrete is not satisfactory or the Engineer judge that the sections of the concrete work are defective, then the condemned concrete shall be cut out removed and replaced by the Contractor at his own expense.

In the event of the works cube tests showing concrete strengths consistently higher than those specified, the Engineer may authorize a reduction in the number of tests.

2. Water Tightness Tests

On the water tightness concrete being used shall be carried out simultaneously with the works cube tests. On each occasion 3 test specimens shall be taken in accordance with DIN 1048 Clause 14-16 or with the method detailed herein under.

Test specimens 20 x 20 x 12.5 cm shall be made in moulds constructed or non-water-absorbent material, the bottom of which shall be made in one piece.

When casting the test specimens all stones larger than 32 mm shall be removed from the concrete which shall be compacted with 40 strokes of a steel bar, approximately 50cm. long and 20 mm diameter with a round end. The mould shall then be filled to overflowing, compacted as before and the excess struck off. For compaction using a vibrator the mould shall be filled and vibrated. It shall then be filled to overflowing, vibrated again and the excess struck off. On no account shall poker vibrators shall be used to the concrete. For about 24 hours, subsequent to casting the test specimens shall be covered with wet hessian and stored at 20 ± 2^0C before striking the mould. The test specimens shall then be stored in water or wet sand or sawdust at the above temperature until 5 days after casting. For the rest of the time until testing at 28 days after casting they shall be stored at the same temperature in air and protected from drying out.

Water at a pressure of 8 ± 0.3Kg/cm² shall be applied to the bottom face over a circular surface of 17 cm diameter for 23 ± 2 hours.

The concrete is taken to be watertight if the upper surface of the test specimen is still dry after the test. The specimen is to be cut in half after testing and the depth of penetration of the water measured.

Not-withstanding anything contained in this Clause the Engineer may at any time request samples for testing at a government or independent laboratory.

4B.7.12.5 Reinforcement Steel

Notwithstanding that Manufacturer's test certificates shall be supplied when required for all classes of reinforcement, the Contractor shall provide sufficient specimens for three tensile tests and three cold bend tests for each ten tons of bars or fraction thereof and for each different size of bar.

The specimens shall be sampled under the direction of the Engineer and tests to determine the steel analysis and the tensile and cold bend properties of the steel shall be carried out in accordance with the requirements of B.S.4499 supplies of reinforcement shall be rejected if the average results are not in accordance with the requirements of the Specifications.

4B.7.12.6 Costs of Testing

The Contractor shall bear all costs involved in the providing obtaining, collecting, cutting out or sampling of all specimen samples of sand aggregates cements, concrete steel reinforcement, water or other materials required for testing in accordance with this specification.

As herein before detailed he shall also bear all costs of making test cubes specimens and other test pieces as may be required and provide all necessary equipment for carrying out the site tests specified including the provision of all testing equipment stoppers hoses, valves, gauges, recording instruments and the like. He shall also arrange for and bear all costs involved in the transportation of such samples to the Central Laboratory or the Government Research Station or to the approved laboratory in Kuwait as directed by the Engineer.

4B.7.13 Design Specification

The design of the works shall be carried out in respect of all reinforced concrete in accordance with the requirements and recommendations of CP.8110, CP.114 and BS. 8007.

4B.7.14 Metal Beam Guard Rail

4B.7.14.1 Description

The Contractor shall construct all guard rails complete with posts, foundations, end sections etc., all as shown on the Drawings and in accordance with the lines and grades as directed by the Engineer. The Contractor shall submit to the Engineer for his review and approval shop drawings complete with all details of the type of corrugated steel beams guard rail and fittings he proposes to use on this project.

Steel posts shall be as shown on the Drawings. Sections shall conform to AASHTO M180. They shall be form rolled to the shapes indicated on the Drawings and shall be hot-dipped galvanized in accordance with AASHTO M111.

Steel rail sections shall conform to AASHTO M180. They shall be form rolled to the shapes indicated on the Drawings, and shall be hot-dipped galvanized in accordance with AASHTO M111.

All fastenings shall be either wrought iron or medium steel and shall be galvanized in accordance with ASTM A153.

4B.7.14.2 Construction

Guard rail of the kind and type shown on the drawings shall be constructed at the locations shown thereon as determined by the Engineer**.**

All posts shall be set vertically in the positions shown on the Drawings. Post holes for steel posts shall be surrounding of Class N25 concrete tamped into place.

Steel rail sections shall be cut, punched and/ or drilled in the shop prior to galvanizing. Special detail holes may be cut in the field only when necessary and if approved by the Engineer**.**

All nicks, gauges and scratches in the galvanized surface of the railing shall be painted with a high zinc content paint. The railing and posts shall be painted as described in this specification.

4B.7.14.3 Railing

Description: The Contractor shall construct all railings complete with rails, posts, holding-down bolts and rail joints as shown on the Drawings and in accordance with these specifications**.**

4B.7.15 Polyethylene Sheets

1. **Tensile Strength and Elongation**

   Test to be carried out in accordance with BS.2782-Part 3-326A to 326C.
   Tensile Strength - 18 - 21 N/sq.mm.
   Elongation - 430% - 500 %

2. **Tear Strength**

   Test to be carried out in accordance with 2782 Part 3 Methods 360B
   Tear Strength - 105 - 117 N/sq.mm.

3. **Melt Flow Index**

   Test to be carried out in accordance with BS.2782, part 7-720A

4. **Water Vapour Permeability**

   Test to be carried out in accordance with BS.3177.

4B.7.16 Bituminous Protection

Bituminous protection shall be applied to all external surfaces of the reinforced concrete Reservoirs walls, valve chambers, drainage manholes and all reinforced concrete structures below ground level except the Thrust Blocks or where concrete is to be cast against blinding or undisturbed soil**.**

The surface to be protected shall be smooth and true and shall be dry and free from all dirt, grease, oil and other deleterious matter both before the application of primer and between subsequent successive coats of paint.

The surface shall then be treated with one coat of approved primer well worked in to ensure complete coverage.

Two coats of an approved rubber-rich high build bituminous paint shall be brush applied to provide a continuous coating of total dry film thickness not less than 200 microns.

The two coats shall be of different color, the primer and top coats shall be compatible and obtained from the same manufacturer whose application instructions shall be strictly adhered to primer and paint shall be to the approval of the Engineer.

Where bituminous protection is provided to the external concrete surfaces of substructures to buildings and manholes the bituminous protection shall terminate at finished ground level**.**

4B.7.17 Expansion Joint Filler (Sponge Rubber)

Sponge rubber Joint Filler shall have the following physical properties:

Polymer	-	Neoprene
Color	-	Black
Density	-	30 p.c.f. min
Recovery	-	90% min
50% Compression Deflection	-	50 to 1, 500 p.s.i
Extrusion	-	0.25 in max
Tensile strength	-	20 p.s.i. min
Elongation	-	75% min
Meets the following Specifications	-	ASTM D-1752 Type 1 KHF-341e-11A AASHO M153-54 TYPE 1
Shrinkage %- Linear Maximum	-	1.5%

Temperature Resistance

Low	-	-30 F
High Continuous	-	150 F
High Intermittent	-	200 F

4B.7.18 Elastomeric Neoprene Bearing Pad

Bearing Pads for the sliding joints between wall and roof slabs in the ground reservoirs shall be of "Neoprene Grade 50" and the Contractor may use the approved product of any manufacturer provided it has the following physical properties tested in accordance with ASTM D15, Part B.

Grade (Durometer) - 50

Original physical properties:

Hardness ASTM D2240 - 50 +/-5.

Tensile Strength, minimum PSI, ASTM. D412 - 2.500 (175 kg/cm^2)

Elongation at break, Minimum percent - 35

Accelerated Tests to Determine Long-term Aging Characteristics:
(Oven Aged-70 Hrs./212^0 F.= 70 Hrs./100^{0}C ASTM D573)

Hardness, points change, maximum - 0 to +15

Tensile Strength, % change, maximum - +/- 15

Elongation at break, % change, maximum - 40

Ozone (1 ppm in Air by Volume - 20% strain-100)
(= 38 ± 1^0 C),ASTM D1149) - + /- 2 ºF

100 Hour - No cracks

Compression set (22 hrs./158°F = 22hrs./70°C)
ASTM D395 - Method B % maximum - 25

Low temperature stiffness (ASTM D 797)
At -40°F = (-4.4°c) Young's modules, maximum psi 10,000 (700 kg/cm²)

Tear test (ASTM D-624), Die "C")
Pounds/lin. in., minimum - 250 (45 kg/cm).

4B.7.19 Waterproofing Membrane

Waterproofing membrane shall be a pre-termed strong impervious torch applied laminated bitumen/polythene membrane with a minimum thickness of 4mm. All necessary ancillary materials such as primer, mastic, adhesive, fillet, protection boards, etc., shall be used and the manufacturer's instructions and recommendations shall be followed strictly.

The following is appended to specification of the road works.

4B.8 SIGNAGE:

4B.8.1 Description

i. Provide all labor, materials, equipment, services and accessories necessary to furnish and install the work of this Section, complete and functional, as indicated in Documents and as specified herein.

ii. The principle work of this Section includes, but may not be limited to the following:

4B.8.2 Traffic Signs

The work of this Section is all signage and display items specified herein.

4B.8.3 Reference Standards

The work shall conform to the Codes and Standards of the following Agencies as further cited herein:

i. Kuwait Municipality.
ii. Kuwait Ministry of Public Works, Roads Administration.

4B.8.4 Shop Drawings

Submit Shop Drawings for approval of the Engineer and all other approving authorities. Show plans, elevations, details and job conditions, relationship to other work, and indicate finishes.
Take measurements in the field and verify all dimensions before submitting shop drawings.

Drawings shall show in detail the various portions of the work, graphic and art layouts, kind of materials, size of members, and methods of securing same together and to work of other trades.

Where provisions must be made for attaching other materials to work included under this Section or where provisions must be made for assembly and installation in the field, the required cutouts and attachments shall be provided in the shop. All such items shall be indicated on the Shop Drawings.

4B.8.5 Mock-Up of Sign Types

Submit full size mock-up of all sign types (one per sign type) to simulate:

i. Text, size, letter spacing and color.
ii. Panel size and exact panel color.
iii. Overall unit height and width.

Mock -ups are to test legibility of text on sign panel.

Contractor has option of using choice of materials for mock-ups. Mock-ups shall be prepared in advance of fabrication so as not to delay work and shall be submitted to site for approval by the Engineer and Employer before any work is commenced.

4B.8.6 Quality Assurance

Manufacturer: The approved manufacturer shall have at least five years' experience in the type of work required; shall have a reputation for doing satisfactory work on time and shall have recently successfully completed similar work.

4B.8.7 Delivery, Storage and Handling

Deliver and store materials in a manner to prevent mechanical damage or damage by the elements.
Deliver materials to site in ample time to avoid delay in job progress and at such times as to permit proper coordination of the various parts.

4B.8.8 Traffic Signs

The design, materials and construction of all signs shall comply with the requirements of the General Specification for the Kuwait Motorway/Expressway System (December 1982) Section VII prepared by the Ministry of Public Works, and the Traffic Signs Manual prepared by the Kuwait Municipality.

4B.8.9 Installation

i. The site erection and construction of all signs shall comply with the requirements of the General Specification for the Kuwait Motorway/Expressway System (December 1982) Section VII

prepared by the Ministry of Public Works and the Traffic Signs Manual prepared by the Kuwait Municipality.

ii. Prior to installation of any sign type verify in field as to its meeting the field condition. Notify Engineer if signs do not meet field condition.

iii. Upon completion all work shall be checked and approval obtained from the Kuwait Municipality Traffic Section.

4B.9 ROADWAY AND PARKING AND MARKING:

4B.9.1 Description

i. Provide all labor, materials, equipment, services and accessories necessary to furnish and install the work of this Section, complete and functional, as indicated in documents and as specified herein.

ii. The principal work of this Section includes, but may not be limited to the following:

- Roadway and Parking Marking**.**

4B.9.2 Reference Standards

The work shall conform to the Codes and Standards of the following Agencies as further cited herein:

i. Kuwait Municipality.
ii. Kuwait Ministry of Public Works, Roads Administration.

All roadway markings shall be in accordance with the Kuwait Municipality Traffic Signs Manual and the General Specification, Kuwait Ministry of Public works Roads Administration.

Traffic signs and traffic markings shall comply with Kuwait Ministry of Public works Traffic Manual dated September 1988.

Traffic markings such as lines, arrows, parking bays and areas of no parking shall be marked out with paint, all markings shall be white except arrows for exit paths and no parking areas, which shall be yellow.

4B.9.3 Submittals

Submit to the Engineer the manufacturer's specification and installation instruction for paint materials and systems, including certifications, verification of mil thickness, specified and other data to show compliance with these specifications.

4B.9.4 Quality Assurance

i. Where manufacturer makes more than one grade of any material specified use the highest grade of each type, whether or not the material is mentioned by trade name in these specifications.

ii. All containers shall have labels clearly showing the manufacturer's name, the product name and number, the color and the batch number.

4B.9.5 Environmental Conditions

Paint shall not be applied in rain, fog or mist, or when the air is dust laden or when the relative humidity exceeds 85%. Paint shall only be applied to surfaces that are completely free of surface moisture as determined by sight or touch**.**

4B.9.6 Delivery, Storage and Handling

i. All materials shall be stored in designated spaces in a manner which meets the requirements of applicable codes and fire regulations. When not in use, such spaces shall be kept locked and inaccessible to those not employed under this Section Each space shall be provided with a fire extinguisher of carbon dioxide or dry chemical type bearing the label of the National Board of Fire underwriter's and tag of recent inspection.

ii. All materials shall be brought to the building and stored in the mixing room in manufacturer's original sealed containers, bearing the manufacturer's standard label, indicating type and color. Materials shall be delivered in sufficient quantities in advance of the time needed in order that work will not be delayed in any way.

4B.9.7 Materials

i. All materials shall comply with the General Specifications.

ii. Marking paint: Modified alkyd synthetic resin paint with elastomeric additive such as chlorinated rubber especially manufactured for pavement marking.

iii. Glass powder as recommended by paint manufacturer for mixing in paint prior to application.

4B.9.8 Execution

i. All execution shall comply with the General Specifications, Roads Administration.

ii. Surfaces to receive marking shall be cleaned, dried, fully cured and made ready for application of paint.

iii. Accurately measure, layout and apply chalk lines in the required marking configuration as indicated on drawings for traffic and parking areas.

iv. Comply with manufacturer's application instructions. Paint the lines and other markings with neat edges. Apply paint in coating of minimum 0.125 mm. wet film thickness, and as required to obtain solid markings without voids.

4B.9.9 Protection

i. Place paint or solvent soaked rags, waste or other materials which might constitute a fire hazard in metal containers and remove from premises at the close of each day's work. Take every precaution to avoid damage by fire.

ii. Re-finish any work made unnecessary by defective workmanship or materials, or carelessness as directed by the Engineer.

iii. Provide temporary barricades to prevent damage to paint markings before it has dried. Repaint damaged markings and remove paint smears, splatters and blotches.

4B.10 NON–TOXICITY TEST REQ. FOR PRODUCTS IN CONTACT WITH DRINKING WATER:

4B.10.1 All products which come in contact with drinking water shall be tested for non-toxicity in an independent laboratory approved by ANSI/NSF and shall be tested as per ANSI/NSF 61 standards.

4B.10.2 The products coming in contact with drinking water will be exposed continuously at approximately 48ºC in Kuwait. Therefore, the products shall be tested according to ANSI/NSF 61 “Commercial Hot Applications" for continuous hot water exposure.

i. Pipe and related products:
Products shall be tested for end use temperature 60 ± 2° C (140 ± 3° F)

ii. Barrier materials:
Products/materials shall be tested at temperature 60 ± 0.5º X (140 ± 1° F)
(As per Annexure-B). Sample size 50 cm²/L

iii. Joining and sealing materials:
Products/materials shall be tested at temperature 60 ± 0.5º X (140 ± 1° F)
(As per Annexure-B). Sample size 15 cm²/L

iv. Mechanical devices:
Shall be as per Annexure-B

v. Mechanical plumbing devices:
Shall be as per Annexure-B

4B.10.3 Test results shall be submitted, evaluated and compared with allowable reaching limits of toxic materials as per annexure of ANSI/NSF 61.

i. TOXICOLOGY review and evaluation, of products shall be done as per Annexure “A” of ANSI/NSF 61.
ii. Products/Materials evaluation shall be done as per Annexure “B” of ANSI/NSF 61.
iii. Acceptable materials are as per Annexure “C” of ANSI/NSF 61.
iv. Normative drinking water criteria as per Annexure “D” of ANSI/NSF 61.
v. International drinking water criteria as per Annex. “E” of ANSI/NSF 61.

4B.10.4 The concentration of leaching materials shall be within allowable limits given in Annexure of ANSI/NSF 61.

4B.10.5 Product of containers shall have printed batch numbers, date of manufacture, date of expiry (stickers not accepted on any condition), Storage and handling conditions. Test laboratories logo shall be on cans, indicating materials can be used in contact with drinking water.

4B.10.6 The Contractor shall submit original authenticated non toxicity certificate (authenticated by Embassy and Ministry Of Foreign Affairs), issued by ANSI/NSF approved laboratory along with letter addressed to Under Secretary, Ministry of Electricity & Water from the testing laboratory. In the event of Contractor is unable to submit the above non toxicity certificate, The Contractor shall be required to test the material for non-toxicity on MEW request at ANSI/NSF approved laboratory at his risk ad cost in the presence of Third Party appointed by MEW.

4B.11 WATER PROOFING MEMBRANE OVER JOINT IN THE ROOF SLABS OF RESERVOIR:

Roof joints shall be treated with water proofing membrane 3 mm thick (fluid applied as per specification) at a minimum width of 25 cm. To stop any possible leakage through the water stop, bond breaker tape should be placed between sealant and water proofing membrane.

The liquid water proofing membrane (fluid applied as per specification) shall be reinforced by approved fiber mat 18 cm wide. The top surface of roof slab where the water proofing membrane is to be placed shall be sand blasted and appropriate primer shall be used to give strong bond between concrete and water proofing membrane.

Water proofing membrane shall have specifications and characteristics as per clause No. 4B.7.19

4B.12 WATER PROOFING MEMBRANE OVER JOINTS (NON TOXIC):

The top surface of all joints inside the reservoir shall be treated with water proof membrane 4 mm thick (fluid applied as per specifications) for a minimum width of 40 cm to stop any possible leakages through the water stop. Bond breaker tape should be placed between sealant and water proofing membrane.

The water proofing membrane shall be reinforced by proper fiber mat 30 cm wide so that the membrane has enough strength to resist water pressure. The top surface of floor slabs and walls, where the water proofing is to be placed shall be sand blasted and primer used to give strong bond between concrete and water proofing membrane.

4B.13 POTABLE WATER TANK LINERS (WATER PROOF MEMBRANE)

4B.13.1 General

4B.13.1.1 Section Includes

Potable water tank liners (water proofing membrane) for concrete tanks should be two component urethane chemically cured applies as a cold liquid, which rapidly cures to form a seamless, abrasion, corrosion and chemical resistant water proofing membrane for applications requiring classification in accordance with ANSI/NSF 61.

The water proofing membrane shall be subjected to continuous immersion in water of 50° temperature. Manufacturer's written confirmation regarding its suitability in the above conditions would be required. The material shall be tested for non-toxicity at 60° ± 0. 5° C (continuous water exposure) as barrier material. Minimum sample size shall be 50 cm^2/L as per ANSI/NSF 61.

4B.13.1.2 Related Sections

Coating system concrete storage tanks

4B.13.1.3 Code References

i. ACI 201. IR - Making a condition survey of concrete in service.

ii. ANSI/NSF 61 - Drinking water system components – Health effects.

iii. ASTM C 836 - High solids contents, cold liquid applied Elastomeric water proofing membrane for use with separate wearing course.

iv. ASTM C 957 - High solids contents, cold liquid applied Elastomeric water proofing membrane for use with integral wearing course.

v. ASTM D 36 - Softening point of bitumen (Ring and ball apparatus).

vi. ASTM D 257 - D-C Resistance or Conductance of Insulating materials.

vii. ASTM D 412 – Vulcanized rubber and thermoplastic elastomers -Tension.

viii. ASTM D 624 – Tear strength of Conventional vulcanized rubber and thermoplastic elastomers.

ix. ASTM D 648 – Deflection temperature of plastic under flexural load.

x. ASTM D 751 – Coated fabrics.

xi. ASTM D 832 – Rubber conditioning for Low- temperature testing.

xii. ASTM D 1117 – Testing non-woven fabrics

xiii. ASTM D 1682 – Breaking load and elongation of textile fabric.

xiv. ASTM D 2240 – Rubber property – Durometer Hardness.

xv. ASTM D 3786 – Hydraulic Bursting strength of knitted goods and Non-woven fabrics: Diaphragm Bursting strength test method.

xvi. ASTM D 4060 – Abrasion Resistance of Organic coatings by the Taper Abraser.

xvii. ASTM D 4258 – Surface cleaning concrete for coating.

xviii. ASTM D 4259 – Abrading Concrete.

xix. ASTM D 4263 – Indicating moisture in concrete by the plastic sheet method

xx. ASTM D 4285 – Indicating oil or water in compressed air.

xxi. ASTM D 96 – Water vapour transmission of materials.

Contractor shall supply copies of above codes free of charge to MOE.

4B.13.1.4 Submittals

i. Comply with requirements of submittals procedures.

ii. Product Data: Submit manufacturer's product data, including surface preparation, application, curing, disinfection instructions and material safety data sheets.

iii. Samples: Submit 6 inch x 6 inch (150 mm x 150 mm) samples for approval by the Engineer.

1. Cured membrane, 4 mm thick.
2. Cured material for vertical joints and surfaces.
3. Reinforcing fabric and joint cover sheet.

iv. Potable water certification: Submit certification that liner has been classified by an ANSI certified laboratory to ANSI.NSF 61 in tanks, pipes and joints.

v. Applicator's Project Reference: Submit list of completed project references for applicator's potable water tank liners.

vi. Certification of Applicator's Supervisor: Submit for Applicator's Supervisor certificate indicating completion of manufacturer's Contractor training program.

vii. Warranty: Submit manufacturer's standard warranty.

viii. Maintenance manual: Submit maintenance manual containing instructions for the Owner on how to properly maintain the water proofing properties of the potable water tank liners.

4B.13.1.5 Quality Assurance

i. Qualifications

a. Applicator: Use applicator experienced in the application of the specified potable water tank liners for a minimum of 5 years on projects of similar size and complexity. Provide list of

completed projects including project name and location, name of the Engineer, Name of liner manufacturer and approximate quantity of liner applied.

b. Applicator's Supervisor: Employ a supervisor during all phase of the work that has successfully completed manufacturer's Contractor training program.

c. Applicator's Personal: Employ persons trained for the application of Potable water tank liners.

ii. Regulatory requirements

Comply with environmental regulations.

4B.13.1.6 Delivery, Storage and Handling

i. Delivery:

a. Deliver materials to site in manufacturer's original, unopened containers and packaging, with labels clearly indicating manufacturer and material.
b. Do not deliver materials to site more than two weeks before use.

ii. Storage:

a. Store materials in accordance with manufacturer's instructions.
b. Store materials indoors in an area well ventilated and protected from damage.
c. Do not store materials near open flames, sparks or hot surfaces.
d. Store materials on raised platforms and covered by water proof covers.
e. Keep materials containers closed.
f. Keep a copy of the applicable material safety data sheets with each material.

iii. Handling: Protect materials during handling and application to prevent damage.

4B.13.1.7 Environmental Requirements

i. Do not apply in wet weather or when rain is imminent.
ii. Do not apply when the surface may become wet within 4 hours after application.
iii. Temperature of surface should not exceed or less than the limits mentioned in the manufacturer's instructions.
iv. Do not apply to porous substrates when substrate or ambient temperatures are rising.
v. Do not apply to porous substrates when substrate is in direct sunlight.
vi. Do not apply over substrates that are frozen or contain frost.

4B.13.1.8 Warranty

Provide a 5 year material and labour warranty. Obtain material warranty from the manufacturer.

4B.13.2 Products

4B.13.2.1 Manufacturer

Name of the Manufacturer, Address, Telephone, Fax and E mail shall be etched on the drums of the materials.

4B.13.2.2 Potable Water Tank liners (Water Proofing Membrane)

i. Liquid Membrane

The liquid membrane must be Two component, high solids, elastomeric urethane industrial membrane. Designed for spray, squeegee, roller or trowel application and must fulfill all requirements as per the following Table :

1	Potable water service classified for potable water contact in tanks, pipes and joints in accordance to ANSI/NSF 61	Sample size 50 cm²/L. maximum allowable use level at 60° ± 0.5°C shall be given by ANSI/NSF 61 with ANSI/NSF certified laboratory.
2	Elastomeric waterproofing ASTM C 836 AND 957	Should exceed all criteria
3	Solids by volume, ASTM C836, C957	Minimum 85%
4	Volatile Organic Compounds (VOC)	Should comply with VOC regulations or 0.77 pounds/gallons (92 g/L)
5	Mullen burst strength ASTM D 751, 50 mils (1.25 mm)	Minimum 150 psi
6	Tear strength ASTM D 624 inch. (Die.C)	75 pounds per inch of min. thickness.
7	Tensile strength ASTM D 412, 100 mil (2.5 MM) sheet	Minimum 500 psi
8	Extension to break ASTM D 412	Minimum 300 %
9	Membrane weight 60 mils (1.5 mm) wet film thickness	Near 31 pounds per 100 square feet (1.51 kg/m²)
10	Recovery from 100 percent extension	
	a) After 5 minutes	98 %
	b) After 24 Hours	100 %
11	Membrane performance, crack bridging	
	a) 10 cycles at -15° F (-26° C)	Greater than 1/8 inch (3 mm)
	b) After heat aging	Greater than 0.157”(4 mm)
12	Membrane performance, weathering, ASTM D 832	5000 Hours
13	Softening Point, ASTM D 36	Greater than 275° F
14	Deflection temperature, ASTM D 648	Below -60° F (-15.55° C)
15	Service temperature	(-50 to 60°C)
16	Hardness ASTM D 2240 Shore A, @ 77° F (25° C), ultimate hardness	Minimum 30.
17	Permeability to water vapour, ASTM E 96 method E, 100° F (38° C), 100 mil (2.5 mm)	0.03 perms

	sheet	
18	Abrasion resistance, ASTM D 4060 weight loss	1.2 mg.
19	Electrical resistivity, volume ASTM D 257, 50 % relative humidity, 23° C, 2 inch (50 mm) disc, 100 mil (2.5 mm) thickness	1.9 x 10 E,14 ohm-cm Approx.
20	Adhesion to concrete (dry) elcometer	350 psi
21	Time to reach 20 shore "A" hardness at 77° F, 200 g quantity	24 Hours maximum
22	Working life (pot life) @ 77° F	30-90 minutes
23	Color	Black/Grey
24	Set Time to polyethylene film hours ASTM D 1640 procedure 5.3.2	About 4 hours

Non Toxicity for Water Proofing Membrane
Hot Applications, Continuous Hot Water Exposure
Testing at 60° ± 0.5° as per ANSI/NSF 61

Sl. no	Specifications	Maximum Permissible Level, mg/L
A	Metallic Toxicological Parameter: Arsenic Barium Cadmium Chromium Lead Mercury Selenium Silver	 0.025 2.00 0.005 0.10 0.015 0.002 0.05 0.05
B	Phenolic Toxicological parameters: Phenolic substances	 0.05

ii. Primer

Should be compatible with the membrane as per manufacturer's recommendations. Use as a prime coat on dry, porous and non-porous surfaces, such as concrete and steel. Prevents flash rust on blasted steel and minimizes out gassing from porous substrates. Ensure a continuous and uniform bond between surfaces and must fulfill the following requirements:

1	Potable water service	Classified for potable water contact in tanks, pipes and joints in accordance with ANSI/NSF 61.
2	Solids by volume	65 % mixed minimum
3	Volatile Organic Compound (VOC)	2.3 pounds per gallon (275 g/L) or should comply with VOC regulation

iii. Vertical Joints and Non-Horizontal Joints and Surfaces

A non-sag tough liquid applied chemical and corrosion resistant urethene elastomer chemically thickened to allow trowel gun applications suitable to use as crack filler and for application to vertical surface and joints. Catalogue shall give all details as specified above including:

Potable water service: Classified for potable water contact in tanks, pipes and joints in accordance with ANSI/NSF 61- Sample size 50 cm^2/L. ANSI/NSF 61 certified laboratory shall give maximum allowable contact area of material to water at temperature 60 ± 0.5° C.

iv. Reinforcing Fabric for Joints and Cracks

Scrim stitch bonded polyester. Compatible with membrane materials and must fulfill the following requirements:

1	Weights	3 ounces per square yard (100g/m^2)
2	Tensile strength, ASTM D 1682	57.1 pounds (30 kgs)
3	Elongation, ASTM D 1682	61.65 %
4	Mullen Burst strength, ASTM D3786	176.8 psi (1215 kPa)
5	Trapezoid Tear strength, ASTM, D1117	16.1 pounds (7.2 kg)

4B.13.3 Execution

4B.13.3.1 Examination

Inspect substrate and adjoining areas where potable water tank liners will be applied. Notify the Engineer of conditions that would adversely affect the application or subsequent utilization of the liners. Do not proceed with application until satisfactory conditions are corrected.

4B.13.3.2 Protection

Protect adjacent works and surrounding areas from contact with potable water tank liners.

4B.13.3.3 Surface Preparation for Concrete Tanks

i. Prepare surfaces in accordance with manufacturer's instructions.

ii. Provide clean, dry and structurally sound concrete surfaces.

iii. Provide broom finish or float finish to class B tolerance.

iv. Concrete Curing:

a. Allow concrete to cure a minimum of 28 days.
b. Water cure concrete as specified.
c. Do not apply curing compounds.

v. Condition Survey:

a. Perform a condition survey of existing concrete in accordance with ACI 201. IR.
b. Concrete surfaces may be prepared by abrasive or water blasting as specified below:

vi. Abrasive blasting:

a. Prepare concrete surfaces to receive potable water tank liners by abrasive blasting.
b. Remove dirt, soil, grease, oil paint, coatings, from releasing agents, curing compounds, laitance, loose material, unsound concrete and other foreign materials that would inhibit performance of potable water tank liners in accordance with ASTM D 4258 and by abrasive blasting.
c. Obtain a firm, sound concrete surface in which bug holes are fully opened.
d. Remove sharp concrete edges and projections.
e. Perform abrasive blasting in accordance with ASTM D 4259.
f. Receive approval by Engineer of blasting media.
g. Maintain air supply for abrasive blasting free of oil and water in accordance with ASTM D 4285.

vii. Water blasting:

a. Prepare concrete surfaces to receive potable water tank liners by water blasting.
b. Use 5,000 psi (35 Mpa minimum) high pressure water blast.
c. Remove dirt, soil, grease, oil paint, coatings, from releasing agents, curing compounds, laitance, loose material, unsound concrete and other foreign materials that would inhibit performance of potable water tank liners in accordance with ASTM D 4258.
d. Obtain a firm, sound concrete surface in which bug holes are fully opened.
e. Remove sharp concrete edges and projections.
f. After water blasting, remove water and thoroughly dry concrete before application of potable water tank liners.

viii. Repair concrete surfaces to be free of holes. Fully open bug holes before repair. Repair defects in the concrete surface, such as bug holes, air pockets and honeycomb by filling and smoothing off with patching material, epoxy compound or grout. Abrasive blast repaired surfaces.

ix. Repair surface profiles greater than ¼ inch (6 mm) with patching material to a profile less than 1/8 inch (3 mm).

x. Repair cracks in concrete surface with materials suitable for type and width of crack, compatible with substrate and potable water tank liners and approved by the Engineer.

xi. Do not apply primer or potable water tank liner to concrete surface unless the moisture test in accordance with ASTM D 4263 indicates no capillary moisture is present.

xii. Apply primer to concrete surface at 5 mils (125 microns) dry thickness.

xiii. Allow primer to cure in accordance with manufacturer's instructions before top coating with liquid membrane.

4B.13.3.4 Application

i. Apply potable water tank liners in accordance with manufacturer's instructions.

ii. Keep materials containers tightly closed until ready for use.

iii. Keep equipment air supplies and application surface absolutely dry.

iv. Mix and apply when liquid membrane is above 60° F (15° C)

v. Do not use adulterants, thinners or cut back solutions.

vi. Blend and mix 2- component materials in accordance with manufacturer's instructions. Do not hand mix components.

vii. Maintain air supply for material spray application free of oil and water in accordance with ASTM D 4285.

viii. Apply liquid membrane directly to a clean and dry surface or to scrim.

ix. Apply 6 to 12 inch (150 to 300 mm) or as per Bill of Quantity wide strip or reinforcing fabric over cracks over 1/8 inch (3 mm) wide, joints and edges. Centre reinforcing fabric over all joints and adhere by first applying a tack coat of liquid membrane.

x. Apply sufficient liquid membrane to achieve 4 mm/3 mm dry film thickness as per Bill of Quantity for potable water immersion service.

xi. In case of work stoppage or extra ordinary delay due to non-favorable weather conditions or any other unforeseen conditions, the joint locations should be once again re-prepared appropriately.

The joint locations should be sound, straight and completely clean. The overlap of the membrane application at stop ends due to time gap, shall be minimum 6 inches (150 mm). Before recoating, the overlap part must be abraded rough with wire brush or sand paper. The manufacturer's recommended bonding agent should be applied before any recoating.

xii. Recoating:

a. Recoat liquid membrane system within 4 hours to obtain maximum interlayer adhesion to build specified thickness.
b. Immersion service: Complete recoating within 4 hours, except at joints.
c. Non Immersion service: Severely abrade with wire brush or surface grinder; apply bonding agent, and recoat, if membrane has cured more than 4 hours.

xiii. Colored or Reflected surface finish:

a. Pigmented topcoat.
b. Tack coat of liquid membrane, with dry aggregate broadcast into wet coating.

4B.13.3.5 Curing

i. Cure membrane in accordance with manufacturer's instructions.

ii. Do not allow uncured membrane to come into contact with potable water.

iii. Curing time:

a. Allow sufficient time for solvent to evaporate from the cured liner before placing into potable water service.
b. Allow minimum solvent release time of 2 weeks at 60° F (15° C) for a 60 mil (1.5 mm) membrane. Other temperatures or thicknesses may require different solvent release times.

iv. Receive approval of cured liner by Engineer before disinfection.

4B.13.3.6 Disinfection

i. Wash, rinse and disinfect the liner in accordance with manufacturer's instructions before placing into potable water service.
ii. Dispose of cleaning and disinfecting solutions in accordance with local regulations.
iii. Receive approval of cleaned and disinfected liner by Engineer before placing into potable water service.

4B.13.3.7 Field Quality Control

Provide inspection services by an independent inspection firm/manufacturer's representative throughout all phases of surface preparation, application, curing and disinfection of liner.

4B.13.3.8 Cleaning

i. Remove and dispose of all temporary materials used to protect adjacent work and surrounding areas.
ii. Immediately remove and clean liner materials from surface not intended to receive the materials.

Waterproof membrane shall be tested in accordance to the latest standard at the cost of the Contractor before and during manufacture at the independent laboratories, place of manufacture as designated by the Engineer for physical and chemical tests. The Contractor shall take into consideration the time factor regarding completion of tests.

Contractor will appoint Inspectors approved by MEW to test and inspect the material during manufacture at the place of manufacture. List of MEW approved inspectors are available in the Ministry. Cost of inspection and testing payable to the inspector would be paid by the Contractor. No

material will be shipped by the manufacturer without the release note of the inspectors; this should be mentioned in the Letter of Credit (L.C).

END OF SECTION

Government of State of Kuwait

Ministry of Electricity and Water

Section 4C.1

Technical Specification for

Distributed Control System (DCS)
And
Process Control Automation System

Contents

1. General:-

a) The specification shall cover the basic requirements of the DCS system.

b) The Complete field instrumentation, DCS and whole telecommunications network system shall be designed as a failsafe fault tolerant, with automatic switchover and continuous automatic test of unused network nodes.

c) The Contractor shall include in his Tender a statement confirming that all the proposed DCS, telecommunications equipment is of current manufacture and has a minimum life expectancy of 15 years. Obsolete equipment will not be acceptable.

d) The DCS, telecommunication and HMI equipments manufacturer shall provide the Spare Parts and Interchangeability Record (SPIR form as per attachment) for the min. of 15 years. The SPIR form to be submitted along with tender technical bid.

e) Instrumentation and control equipment furnished shall be manufactured by a OEM regularly and currently engaged in the design and manufacture of similar equipment. All equipment furnished shall be new and of the most recent design.

f) It shall be the responsibility of the Contractor to ensure that the equipment supplied under this specification are compatible with the primary elements and equipment specified under other Sections of these specifications, and that the signal transmission methods are compatible.

g) All equipment shall be designed for ease of maintenance and repair, and access to critical Parts shall not require any major dismantling. Internal field adjustments where permitted or required herein shall be easily accessible upon removal of a panel or cover.

h) Materials and installation shall comply with the requirements of the current editions of referenced electrical codes and standards as listed below, and the codes and standards referred to shall be used for establishing the minimum quality of the materials and equipment supplied and installed. All equipment of the same type shall be products of the same manufacturer.

i) Manufacturers shall test and calibrate each input/output to operate within specified limits Calibration and compliance certificates provided by the manufacturer, shall be authenticated by the Contractor and submitted to the Employer.

j) Enclosures of front of panel mounted instruments shall be of uniform design and colour scheme wherever possible. Front of enclosure colours shall be compatible with panel colours and subject to final approval by the Employer.

k) The DCS shall be microprocessor based and supplied as a complete standalone system. The type of system shall be selected to be compatible with the system loading

requirements. The systems shall be selected for all applications that fall within their capability for safe, efficient handling of all control, display and update functions.

l) When selecting the size of DCS, due account shall be taken of the expansion of control requirements during detailed engineering and incorporation of the controls for packaged equipment. In addition to the built-in spare capacity, expansion and optional facilities described in this specification, the final DCS employed shall be able to be expanded to encompass the loading of at least 30% additional IO of all types after Project completion, with the associated high-level control algorithms. The system selected shall utilize not more than 50% of its software limitation.

m) The designs proposed shall be optimized in terms of compact, small foot print installation requirements. The system shall be packaged to be economical in terms of space but still allow for easy access for operations and systems maintenance tasks. The functions shall be as follows:

- Provide intelligent control and monitoring of all Facility functions from the field input termination interface through to the field output termination interface.
- Provide a comfortable, user friendly, operator working environment for display and access to all the Facility parameters including graphic displays, controller face plates, alarms and other operator information. Storage, collation and reporting of all necessary data for trending, shift and period logging and condition monitoring.
- To interface with packaged equipment panels and to assist in future expansion, the system shall utilize standard communications protocols registered by recognized authorities such as the International Consultative Committee on Telephony and Telegraphy (CCITT) and the Electronic Industries Association (EIA), and be capable of communications interfacing with all common DCS or PLC systems used for the control of packaged equipment so that the display of alarms, manipulation of controllers, initiation of controller set-point ramps and all other DCS functions can be achieved via the communications links as if they were direct DCS signals.
- Provide system documentation, software status record system and a complete software backup - reload system to retain the Facility on line or aid expedient recovery in case of a fault or failure.

a) Provide all hardware and facilities to enable operation of the system without addition, including all functional equipment and operator aids including but not limited to furniture, paper trays and 2 year's supply of consumables.

2. Summary Scope of work:-

This specification defines the minimum mandatory requirements for a Process Automation System, associated software and support services.

The scope includes to replace the existing PLCs/RTUs and provide the latest updated new DCS based control system for the following sites

1) Mutla High (E14)
2) Mutla Low (E15)
3) South Jahara Water Towers (D14)
4) Jaleeb Al Shoukh Water Towers (D16)

Which includes to Design, Supply, shipping, transport to site, Install, Cabling, Configure, IFAT at OEM origin, SAT, Pre-commissioning and commissioning of failsafe fault tolerant DCS, Telecommunication, Video surveillance, VoIP telephone and associated equipments.

The DCS system shall provide monitoring and control for the safe, fault tolerant effective and efficient operation of the plant. The complete system (Hardware and software) should support open system architecture with fail-safe fault tolerant redundant system and also it should be possible to interface with standard any third party systems as and when it is required.

a. The DCS shall fully comply with all relevant contractual requirements specified in the Scope of Work and Technical Specification of the Contract.

b. Compliance with this specification shall not relieve the Contractor of its responsibility to supply equipment suited to meet the specified service conditions and applicable regulations.

c. Where conflicts exist between this specification and other Drawings, standards, codes and specifications, the most stringent shall be applied.

d. The DCS supplier shall take single source responsibility for the DCS system and the associated third party peripheral equipment, including DLPs, LCPs, printers and recorders and all other equipment necessary for the functioning of the system.

The scope included to prepare new documents and drawings such as P&I D, Cause and effect charts, instrument loop diagram, I/O lists, Data sheets, Instrument index, Cable interconnection Schedule, Functional Logic Flow Diagram, hook-up diagram system, communication network system, DCS I/O mapping and associated server mapping.etc..

The Contractor has to obtain the available existing documents from MEW O & M department, if any further details are required, the Contractor shall make detail site survey including field instruments, junction box, wiring details, cable schedules, cable routing, cable termination and instrumentation details in order to make the complete documents. All the documents/drawings shall be prepared in ISA format with scale and approved by MEW before starting manufacturing.

3. SERVICE CONDITIONS

a) The equipment shall be suitable for continuous operation at a desert location under high ambient temperatures and humidity. The atmosphere at the facility is generally dusty and corrosive and may contain traces of hydrogen sulphide.

b) Instrument systems shall in all respects be suitable for continuous operation in the service conditions stated in the field instrumentation Specification.

c) The DCS system shall be mounted in an indoor air-conditioned location with a normal temperature of 24°C (75°F) and controlled humidity.

d) The DCS shall continue to operate in Heating Ventilating and Air Conditioning (HVAC) upset conditions, when the temperature can fall to 0°C or rise to 60"C. Under these temperature excursions, the humidity can rise upto 95% (non-condensing). The Contractor shall provide a list of users where the equipment has performed satisfactorily in similar conditions for 2 year or longer.

Environmental Conditions

Indoor Installations

Equipment installed in air-conditioned buildings shall be designed to operate in the following environmental conditions:

- Temperature range: 0 degrees C to 60 degrees C.
- Relative humidity: 5% to 95% RH.

Outdoor Environment

It shall be possible to install the I/O system in outdoor environments.

Storage Environment

It shall be possible to store the equipment before installation for up to 6 months in an air-conditioned building under the following conditions:

- The equipment shall be packed in a moisture proof container
- Storage temperature: -40 to 70 degrees C
- Relative humidity (outside the moisture proof container): 5% to 95%.

4. Pre-qualified Manufacturer's / Subcontractors.

The Engineering, supply, installation & commissioning and IFAT (including DCS, Telecommunication and third party device) of all hardware and software shall be done by the below approved vendors and locations.

The Telemetry, Instrumentation and Control whole works to be executed by the DCS manufacturer from the origin as listed below,

If the tenderer proposed any other middle east office such as Kuwait, UAE, Bahrain, Qatar, Oman, Korea, China, India, Egypt or any other international counties are not approved.

1- Honeywell – USA
2- Invensys System Inc. (Foxboro) – USA
3- ABB- Germany
4- SIEMENS- Germany
5- Yokogawa – Japan
6- Emerson -USA
7- Mitsubishi Heavy Industries –Japan

5. STANDARD SPECIFICATIONS:-

Instrumentation, systems and equipment shall conform in design, materials and performance, except where otherwise specified, with the current issue latest edition and amendments of the applicable codes and standards prevailing on the effective date of the Contract:

a) Reference International Standards

- **<u>International Electro-technical Commission (IEC)</u>**

- IEC 60751 (1983-01) Industrial platinum resistance thermometer sensors
- IEC 61000-4-2 (2001-04) Electromagnetic compatibility (EMC) - Part 4-2: Testing and measurement techniques-Electrostatic discharge immunity test.
- IEC 61000-4-3 (2002-03) Electromagnetic compatibility (EMC) - Part 4-3
- IEC 61000-4-4 (1995-01) Electromagnetic compatibility (EMC) - Part 4: Testing and measurement techniques-Electrical fast transient/burst immunity test.
- IEC 61158 (2000-08) Fieldbus standard for use in industrial control systems - Part 2: Physical Layer specification and service definition.
- IEC 61131-3 (1993-03) Programmable controllers - Part 3: Programming languages
- IEC 61508: Functional Safety, Safety Related Systems

- IEC 60381-2, Analogue d.c. signals for telemetry and control
- EN 50014 to 50020, Enclosure Protection
- IEC 61000-4, RF Protection
- IEC 61131-3, Programming Languages for Programmable Controllers
- IEC 61 7 Graphic Symbols for Diagrams
- IEC 6075 :Industrial Platinum Resistance Thermometer Sensors.

IEC 61000-4-2
IEC 61000-4-3 } :Electromagnetic Compatibility (EMC).
IEC 61000-4-4

IEC 61499-1 } :Function Blocks for Industrial Process measurement
IEC 61499-2 } and control systems.

IEC 61131-3 : Sequential Functions charts.

IEEE C371-1994 : Protective relay and relay system standard.

IEC 60068 : Heat cycle test.

- BS EN 60529, Ingress Protection
- ISA S18.1 Annunciator Sequences and Specifications

- **National Fire Protection Association**
  NFPA 70 National Electrical Code
- **Underwriters Laboratories**
  UL Certificate
- **Canadian Standards Association**
  CSA Certificate
- **ISO-9001**
  The supplier's quality management system fulfills all the specifications of the ISO 9001 standard.
- **GMA-NAMUR**
  The system fulfills the requirements specified by the GMA-NAMUR committee on validation.

NA= NAMUR Worksheet (Arbeitsblatt)
NE= NAMUR Recommendation (Empfehlung)

- **CENELEC / ATEX**
- Guideline 94/9/EG for Explosion Protection
- **NEC (National Electrical Code) Standard 500**
- **ISA/ANSI**
  S88.01 – Batch Control Part 1: Models and Terminology
- **DIN 40 050 / IEC 529 / VDE 0470/ EN 60529**
- **Defines Degrees of Protection**

- The DCS and Telecommunication equipment manufacturer shall submit the Compliance/Non-Compliance Statement with technical proposal and indicate clearly if any deviation on the material or design concept.

- If any deviations or non-compliance with this specification shall be clearly stated in writing by the manufacturer, detailing the paragraphs, reasons for non-compliance and any proposed alternatives. Failure to do so shall be interpreted to mean that the services and equipment provided complies fully with this specification.

6. TECHNICAL SPECIFICATIONS FOR DCS SYSTEM:-

a. General

Hardware and software must be for the most part scalable to fulfill the wide-ranging requirements.

The system should provide a server architecture or client-server architecture.

The system must provide common hardware and development tools for various solutions.

The system must be designed for DCS and third party PLC applications. It must be capable of fulfilling high-speed requirements.

The system must offer integrated fail-safe features in runtime and engineering.

The system must support field bus devices from any manufacturer without additional certification.

The DCS vendor system must contain a high-performance HMI product which is owned, developed, manufactured and tested by the vendor.

The vendor system must support separation between the terminal and system bus. Connection to an office bus may not lead to a problem.

The controllers of the system must allow operation without a fan.

b. Horizontal Integration

The system shall provide integration of process control tasks and upstream and down stream discrete control tasks such as raw material handling and packaging, permitting economical plant-wide integration of all operations in any manufacturing and process environment.

c. Vertical Integration

The system shall support vertical integration by utilizing uniform data communication structures to support complete integration from the control and field levels.

d. Open System

The system shall be an open system composed of standards-based technology including PC platforms with a Windows operating system, Ethernet communications, TCP/IP, OPC for interconnectivity of multiple systems from different suppliers, field mountable control system, remote IO subsystem, and bus-based serial communication with field devices over PROFIBUS-DP, Foundation Fieldbus H1, HART, and Modbus networks.

The system software is resistant to third-party programs. It must be possible to install all system components. The use of virus scanners must be possible. The DCS controllers shall be protected via. Firewall.

e. Centralized and distributed server Architecture with virtualization

a) The control of the Facility shall be centralized at the control centre building. All process management systems shall be placed in the control room or auxiliary room and all systems shall report to the DCS to provide a single-process view for the operator.

b) The scope of this specification is for DCS-associated equipment mounted within the control room, auxiliary room, engineer console room and the training room of the control building. For completeness, the following description includes the field arrangement and mentions items for other systems, which are to be taken into account in the equipment layout and interface. All layout and space allocation calculations shall be performed in conjunction with those for the ESD system, and other equipment are being for installation in the control and auxiliary rooms.

The system shall have a decentralized with distributed client/server architecture allowing extensive scalability. The system shall be expandable and support to additional engineering workstations, operator displays in future – where each station has access to the entire plant, twelve fault tolerant redundant servers, and unlimited process tags to be provided at each sites.

f. Redundancy

The DCS system shall provide fail-safe fault tolerant full redundancy at all levels to provide a high-level of fault tolerance. Operator stations, servers (including third party system such as Large screen stn, Alarm Management system, etc..,) Historian, the terminal and system buses, controllers, field networks, and I/O modules or channels shall be capable of being made redundant as required.

g. Fail-safe Controllers

DCS controllers shall provide fail-safe control operation available using standard controller hardware and special fail-safe I/O modules, using redundant configurations. Programming of fail-safe applications shall use the same engineering environment as configuration of process applications.

The system shall support modules with high degrees of protection (for example, IP42x). As specified in the spec.

h. Licensing

a. For the complete software timely unlimited non-transferable original licenses for all computers of the system are required.

b. Software licenses for engineering workstations and for operator interface consoles shall be independent of the type and mixture of I/O used (analog vs. discrete, input vs. output).

i. Written Explanation of Licensing Practices

To help minimize risk associated with changes in project scope, if software is licensed on a tag-by-tag basis the vendor shall supply in writing details on how the required software license would change under the following circumstances:

- If the total number of system I/O was increased
- Modifications to the set-up of I/O modules (e.g. converting 20% of the discrete inputs into analog inputs.

This only applies when the vendor cannot fulfill the demands mentioned in chapter h. It in no way implies dilution of the requirements described there.

- If the user would like to pass real-time variables from his system to a 3rd party OPC Client.

j. Smart License Model

The vendor must provide a clearly delineated licensing model.

The vendor must offer a licensing procedure that is based on the number of process objects (PO) for OS and controller in the application.

The engineering system must control and count the POs.

k. Use of Standard Products

a) The system shall be composed of manufacturer's standard hardware, systems software, and firmware that can be configured to meet the stated requirements. The vendor's standard system operating software shall not be modified to meet any of the user's requirements.

b) Application software shall be designed in a manner that requires no modification to the system operating software.

c) Software design shall be such that future revisions or updates of the system operating software will not affect the successful operation of the system.

d) The vendor must offer the same platform for safety applications.

l. Spare Capacity and Expansion

a. Each system shall be supplied with 20% spare capacity for each I/O type in the base system. The base system is defined as the quantity of hardware needed to meet the project requirements.

b. Communication networks shall be designed to allow for system growth of at least twenty percent (20%) based on the number of unused node addresses. System expansion shall be achievable without shutting down the controllers not directly involved with the expansion.

c. System Runtime and Engineering Software shall be capable of being expanded by the purchase of additional licensing units.

d. The DCS shall be configured in order to facilitate changes and additions. An expansion shall be possible without changing the system structure and without losing any functionality.

e. The system must allow hardware extension such as additional main and mass store and shall also make automatically use from these additional resources.

f. For further extension it shall be possible to extend the communication units without changing the application software, furthermore it shall be possible to change the transfer protocol without any influence to the other system components.

g. All parts of the system shall be easily (without rebuilding or major shutdown) expandable.

h. The complete software system must be portable up to a reasonable amount. This requires that all programmes have to be standardized and to be provided with high level programming languages. All programme parts which are not provided in high level languages shall be indicated in the offer.

m. Software Revision

The Application software shall not require modifications in order to be able to run under new releases of the system operating software. Any new release of system software shall be backward compatible with files created using the previous software releases. When a new release is installed, it must be possible to back up the user data since the manufacturer may change the data with the new release. The manufacture shall install the new revision software until warranty period of the project, without any additional cost to MEW.

6.1Electrical Requirements:-

i. Electrical Area Classification

Buildings containing the control equipment will be rated as electrically unclassified.

ii. Electromagnetic Compatibility (CE Compliance)

Equipment shall meet all electromagnetic compatibility requirements of the IEC 61000-4-2, 61000-4-3, and 61000-4-4 standards.

iii. Wiring and Cabling

PROFIBUS, Ethernet, and other communication cables shall maintain a minimum separation of 75 mm from any AC power cables(if it is specified). Fiber optic cables are excluded from this requirement.

Vendor installed cables shall be designed and installed in such a way as to allow cable disconnection in order to service the equipment. Cables shall not interfere with circuit board removal.

It should be possible to use safe connectors without short-circuit and the risk of missing connection.

iv. Cabinet and Workstation Grounding

AC Safety ground and instrumentation circuit ground shall conform to the NEC, Article 250.

v. Circuit Boards

It shall not be necessary to remove power or field wiring to replace a control or input/output module.

6.2 DCS Controller:-

i. Multipurpose Controller

The DCS controller shall be a multipurpose controller capable of executing fast programs (discrete) and DCS-style applications (regulatory) allowing process and machinery control to be integrated in one device. Extremely short instruction processing times down to 10 m sec, required for programmable logic control, and slower processing times required for process control, shall both be available. A minimum of 6 independent scan rates should be available for optimizing the execution time of the application program.

ii. Large Capacity Controller

The vendor shall provide a large capacity controller capable of executing a minimum of 100 standard PID Control loops with a 250 msec. scan rate to reduce the need for partitioning of the user application program.

A controller of the upper performance class shall be offered with Memory of 30 MB or better as per manufacturer standard.

A firmware update must be possible for redundant systems during ongoing operation.

No connected engineering system containing required data in the controller must be necessary hot/standby restart.

The vendor system shall not encounter high CPU load or memory requirements for saved texts in the controller. The variable length texts are to be stored in a text database.

iii. Controller hot/standby fault-tolerant Redundancy:-

For high reliability applications, hot/standby fault tolerant redundant controllers, power supplies, Ethernet connections, racks, and Profibus networks shall be provided.

iv. Switchover Time with Redundant Systems:-

The redundancy function of the Controller to be equipped with automatic failover control if the processor in control mode fails, watchdog detection circuitry disables the I/O interface of the primary processor and informs the backup processor of the failure. The backup processor then begins to execute the process control application program and broadcast information over the Network. The Controllers use a continual process of control memory updating to keep both the control and backup processors synchronized. This allows the algorithms to track the output values, pass the information upstream, and apply the data during the first pass of execution. The result is a bumpless failover, even in the case of a malfunction. A full range of events can trigger automatic failover, including:

- Control processor failure
- Network controller failure
- I/O interface failure
- Removal of power from the control processor
- Control processor reset

Once the control is passed to the backup processor, the failed processor may be powered down, repaired, and powered back up with no harmful effects on the executing control strategy. On restart, the repaired processor will detect that its partner is in control and assume the backup role. The processor in control will detect the presence of the backup processor and adjust for redundant operation.

6.3 Power Requirements

Power Supply

There shall be a choice of a 24 VDC or 115/240 VAC 50 Hz power supply.

Battery Backup

Controller configuration memory shall have a battery backup so that the controller maintains its configuration and state information in the event of an extended power outage. The program execution shall restart where it left off upon power restoration.

Response to Power Failures

In the event of an extended power failure the controller shall not require access to the engineering station to reload or redo any portion of its configuration.

The system must ensure that programs are not deleted if power fails. This should be ensured with battery backup.

6.4 Configuration Languages

Configuration languages shall be offered that are traditionally associated a DCS environment. These shall include the following six programming languages including those described in standard IEC 61131:

- Continuous Function Charts (CFC)
- Sequential Function Charts (SFC)
- Structured Control Language (SCL)
- Relay Ladder Logic (R-LAD)
- Instruction List (STL)
- Function Block Diagram

➢ Closed-loop-control

Standard software algorithms shall be available to perform regulatory control functions, and these shall have easily configurable parameters.

➢ Control Modes

It shall be possible to put any individual control loop in a manual; automatic, or cascade mode. In cascade, it shall be possible to configure remote set points from other regulatory controllers or from other control blocks.

There shall be bumpless, balanceless transfer between all control modes, and windup protection shall be provided.

Control blocks shall be able to perform automatic mode switching based on external or internal logic inputs.

➢ Calculations

Algorithm calculations shall be performed in floating-point engineering units or other such equivalent methods that do not require scaling.

➢ Input Functions

The following input functions shall be supplied as standard configurable items:

- Square root extraction, for flow measurement
- Linearization of type B, E, N, J, K, L, R, S, T, and U thermocouples
- Linearization of RTDs
- Digital input pulse totalization
- Pulse input to frequency conversion

➢ Computational Functions

The following computational functions shall be supplied as standard configurable items or simple algebraic instructions.

- Addition / subtraction
- Integrator / Accumulator
- Dead time
- High/low select
- Multiplication / Division
- Time averaging
- Signal selection switch
- Exponential polynomial
- Logarithms
- Square root
- Absolute value
- Closing delay
- Min/Max selection
- Smoothing function
- Noise generator
- Signal smoothing / low pass filter
- Alarm delay

➢ Continuous Control Functions

The following control functions shall be configurable items:

- Proportional Integral Derivative (PID)
- Auto/manual with bias control
- Ratio control

➢ Control Loop Execution Frequency (Scan Rate)

It shall be possible to independently select the execution frequency of each device control strategy in the controller. Controller scan rates as fast as 100 times per second (10 ms) shall be possible.

➢ Control Loop Output Functions

The following output functions shall be supplied as standard configurable items and shall be the same regardless of execution in the system controller:

- Linear
- Linear with clamping (high and low restricted)
- Non-linear characterization

➢ **Set point Clamps**

Upper and lower clamps on all set points shall be configurable.

➢ **Discrete Control**

The following discrete control functions shall be supplied as standard configurable items:

- Logic functions -- and, or, not, nand, nor, xor
- Change of state detect
- Set/reset flip-flops
- Timers and counters
- Comparison elements -- greater than, less than, equal to, not equal to
- Multiplexer (selects one of up to 16 signals)
- Positive, negative, and bi-directional edge trigger

The vendor system must be able to support wide-ranging technological modules (controllers, positioners, counters etc.).

➢ **Sequential Control**

Sequential Function Charts (SFC) shall be available. SFC is a structured, IEC 61131-3 compliant, high-level control programming language.
The SFC shall include the following features:

- It shall provide the necessary facilities for real-time control of sequential processes.
- It shall have access to process control and other database information.
- It shall be possible to modify the program logic while other sequences are active.
- It shall support execution of the chart in Manual or Automatic Mode
- It shall be possible to configure multiple states within a single SFC container. This allows for effective coordination of sequences which have more than one mode (e.g. Heating and Cooling) or that contain safe-state logic (e.g. Aborting or Holding Logic)

- The ability to create master SFC elements which can be copied and used throughout the configuration just like a function block. Changes to a single instance of the SFC will result in automatic updates to all other instances in the configuration.
- The ability to automatically create displays for visualization and control of the SFC directly from the controller configuration.
- The SFC editor shall include a test/debug mode which does not write to the outputs
- Manual adaptation following name changes in charts and their references should not be necessary.
- Sequential charts in OS: It must be possible to monitor the sequencer of the vendor system and operators must be able to intervene if disturbances occur in the process.
- It must be possible to perform actions in step transitions.

➢ **Sequential Functions**

The following sequential functions shall be supplied as standard capabilities:

- Hold sequence -Manual or preset time
- Recycle to prior step
- Skip one or more steps
- Automatic Restart at beginning upon completion (Cyclic Operation)
- Configuration of maximum or minimum execution times for steps and transitions
- Ability to configure an optional operator confirmation for each individual transition condition

➢ **Step Control Modes**

The way in which chart progresses from a transition condition to the next step can be controlled according to the following modes:

- Transition – Control is governed solely by satisfying the transition condition
- Confirmation – Control is governed solely by operator confirmation
- Transition and Confirmation – Both the transition condition must be satisfied and the operator confirmation must be entered before the sequence will proceed
- Transition or Confirmation – Either the transition condition is satisfied or the operator confirmation is entered to allow the sequence to proceed

➢ **Phases of a Step**

Each step of a chart shall support the following standard phases of step execution:

- Initialization – For first-time execution of actions
- Execution – For continuous execution of actions until transition condition is met
- Termination – For post-processing to allow an action to be executed once after the transition condition has been met

➢ **Supported Operating States**

The following 16 SFC operating states (per the ISA S88.01 standard) shall be supported natively by the system:

- Ready
- Starting

- Active
- Completing
- Error (Completing)
- Completed
- Holding
- Held
- Resuming
- Error
- Held (error)
- Resuming (error)
- Aborting
- Aborted
- Stopping
- Stopped

➢ **Supervisory Control**

The vendor shall be able to supply standard supervisory control functions fully integrated with the regulatory control functions. The supervisory functions will include the ability to make set point adjustments to selected loops.
It shall be possible for supervisory control applications to be scheduled, run on demand, or triggered by events.
The supervisory system shall have access to the complete database, with privileges to change items such as controller mode and set point.

➢ **Auto Tuning**

An integrated PID auto tuning facility shall be available from the Engineering Station:

- Applicable to processes with slow and fast dynamics
- Used with self-regulating and integrating processes
- Immune to noise and process load disturbances
- Can be used for standard and custom libraries
- Can be accessed directly from the Engineering Station

The PID auto tuning facility shall employ an easy-to-use graphical interface with a setup "wizard" (similar to Microsoft Excel®) to assist engineers and technicians who are unfamiliar with the tool.

➢ **Fault Handling**

Invalid value status shall be generated for inputs and calculated variables.

A value shall be declared invalid if any of the following conditions are true:

- If a value is out of range

- If a value can not be measured or calculated
- If a value is declared invalid by an application program
- If a value is declared invalid by the source instrument

Invalid value status (data quality) shall be propagated through control schemes, and be available at the HMI.

It shall be possible to inhibit the detection and propagation of an invalid value status. This selection shall be available on a per tag basis.

It shall be possible for an invalid value status to be used as a logical input to initiate control algorithm changes.

When a control algorithm's input is declared invalid, it shall be possible to configure the output to fail as follows:

- Hold last good value
- Zero output signal
- User defined output value

In the event of communications subsystem failure, regulatory control algorithms shall continue operating with the last valid information.

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- **Variable Scan Rates of Control Functions**

The control execution rates for analog functions and discrete functions shall be individually configurable.
The minimum scan rate for discrete and analog control functions shall be 20 msec.

- **Cabinets**

Control cabinets shall conform to CE standards for electromagnetic compatibility with the EMC standard (IEC 61000), and ensure protection against unauthorized access, mechanical influences, contamination, and other environmental influences.

The standard cabinet shall conform to IP42.

The controller and I/O modules shall not require the use of cooling fans.

The vendor must offer switches suitable for mounting in switchgear cabinets.

- **Controller Communication over System Bus**

The system bus used for communication between controllers and up to the HMI Servers shall be capable of running at a minimum of 100 Mbps data rate.
Use of fiber optic cables shall be supported, allowing noise free communication between control and operator stations separated by large distances as required by many processing facilities.

The length of the system bus shall be expandable to 150 Km.

The system bus shall support from two to 1024 stations.

For maximum availability, the system bus shall support configuration in a double redundant ring architecture, using either fiber or copper media.

- **Reserve CPU Capacity**

To reserve CPU capacity for future growth and insure rapid software response to process upsets, CPU execution of the configured software application shall not exceed 50 percent CPU time during the course of normal process monitoring and control. Inputs and Outputs

- **General Inputs and Outputs**

Common mode rejection ratios of 60 dB or greater from DC to 60 Hz and normal mode rejection ratio of 30 dB or greater at 60 Hz are required.

Analog input and output modules shall provide pass through capability to exchange non-control data, both PROFIBUS and HART, with asset management applications, utilizing the infrastructure of the system.

The following configurable fail-safe options shall be available for output modules:

- Drive to predetermined analog output, or de-energize for a digital output
- Maintain the last good output value for an analog, or hold for a digital output.

The fail-safe actions listed above shall be taken upon a processor halt, or power supply failure, or a communication failure between the controller and the I/O module, if so configured.

It shall be possible to change modules in remote I/O racks while the rack is powered up w/o affecting communication to the other modules in the rack.

6.5 Remote I/O Architectures

Remote I/O Capability shall be provided native to the system to minimize wiring costs and to eliminate the need for costly "home run" wiring – The system shall support the following remote I/O families:

- Support of Fail-safe Applications
- Integration of HART field devices
- With Integrated Terminal Blocks
- With special-purpose modules such as Motor Starters and Weigh scales
- With various levels of diagnostics and resolution (number of bits)

To achieve flexibility in the placement of equipment, the vendor's system shall support redundant remote I/O installation whereby conventional redundant I/O modules can be located large distances away (up to 6.0 miles / 9.6 km and longer distance fiber-optics are used) from their associated controller.

- **Non-proprietary Communication from Controller to I/O**

Open standards should be used to communicate between a controller and its I/O modules to facilitate connectivity of 3rd party I/O with the same level of system

support (diagnostics and engineering ease of use). It shall not be acceptable to utilize proprietary communication between the I/O and the controller.

Communication between controller and I/O should be in accordance with IEC 61158 (Fieldbus communication).

- **Hot/standby fault tolerant Redundancy**

The system shall support the use of I/O Redundancy whereby a single sensor or actuator is connected to two separate I/O modules via. signal splitter.

To minimize the potential for common cause failures, redundant I/O Modules must be able to be located in physically separate racks. It is not permissible to share a common backplane.

The system should offer optimal integration of redundant Remote I/O racks (RIOs), redundant I/Os and field bus (Foundation fieldbus or Profibus DP), with both redundant models.

It must be possible to create two process tags (process variables) with the same process name and apply integrated redundancy functions without additional programming work.

- **Redundant Analog Inputs**

The system shall be capable of supporting the following types of analog process input signals:

- 4-20 mA DC, 0-20 mA DC, and ±20 mA DC, isolated and non-isolated inputs
- 1-5 V DC, ±10 V DC, and ±1 V DC isolated and non-isolated inputs
- Type B, E, J, K, L, R, S, T and U thermocouples
- Platinum resistance temperature detector (RTD) – Pt100, Pt500, Pt1000, Ni100, Ni1000, Cu10 - per IEC 60751
- High-speed Pulse input – 1, 10, 20, 100, 250, 500 kHz, @ 24 V

Temperature linearization and thermocouple cold junction compensation shall be provided.

Normal resolution shall be a minimum of 12-bits; special modules with 16-bit resolution shall be available.

Typical analog input modules shall operate at 25 °C with a basic error of no more than ±0.25% of input range.

- **Redundant Digital Inputs**

The system shall be capable of supporting the following digital input types:

- 24 VDC (capable of being time stamped to 1 msec accuracy)

- **Redundant Analog Outputs**

The system shall support output types of 0-20 mA, 4-20 mA, ±10 V DC, 0-10 V DC, and 1-5 V DC.

Analog output modules shall operate with an error limit less than the following:

- Voltage ±0.2% of output
- Current ±0.3% of output

- **Redundant Digital Outputs**

The following solid state output ratings shall be available:

- 24 V DC

Relay or solid-state output contacts that are free of voltage and ground shall be available.

Relay outputs with 24 VDC to 120 VDC, 48 VAC to 230 VAC, 5A rating shall be available.

Digital output module with actuator shutoff via low signal or high signal must be available.

- **Redundant Foundation Fieldbus, HART I/O**

The system shall support Foundation, HART, inputs and outputs. The HART interface shall be a module on PROFIBUS, or the HART devices can be connected to conventional analog input/output modules. All components shall have plug and play capability. The engineering system shall be able to read all variables provided by the field device without the need for any additional wiring.

- **I/O, instrumentation and couplers**

The I/O Interfaces and couplers must be integrated in the alarm system of the control system.

The I/O Interfaces and couplers should optionally offer recording of events (SOE Sequence of Events).

The I/O interfaces / couplers shall support Foundation Field bus, Profibus, HART, sensors.

The scan rate for all channels shall not be longer than 120 ms.

A 1 ms time stamp for DI must be available (SOE= Sequence of Event Recording)

The system shall be capable of closed loop scan rates of 10 ms.

- **Field Termination Assemblies (FTA) or Field Marshalling Cabinet (FMC)**

The system shall provide a standard set of Marshaled Termination Assemblies (MTA) as a means of providing fast and easy connection to the field level while preventing wiring faults. These termination assemblies shall provide individual blown-fuse indication and redundant power connections. A common MTA shall support connection to a redundant or non-redundant I/O configuration. Fieldbus Integration

- **General Requirements**

The system shall be able to read all variables provided by the field device without the need for any additional wiring.
Diagnostic information shall be available from the field devices, including device faults, configuration faults, operating mode, and maintenance requests.

- **Compatibility with 3rd Party Devices**

The system shall support all field devices certified by the appropriate standards body for that field bus type and shall not require additional approvals by the vendor of the host system.

6.6 High Speed Fieldbus Segment (H2) / PROFIBUS DP:-

- **High density H2 field bus segments**

The H2 segment (PROFIBUS DP) shall support up to a maximum of 60 slave nodes (devices) such as analyzers, variable frequency drives and motor protection devices where each device is capable of bringing in multiple process measurements. However each pump to be provided separate and dedicated fault tolerant redundant nodes (device).

- **Maximum Communication Bandwidth**

To minimize the number of segments (networks) required the PROFIBUS DP implementation shall support communication rates of up to 12 MB/sec.

- **Interfacing to Redundant Media**

The system shall support connection of redundant slaves to a redundant PROFIBUS segments.

- **Maximum Cable Length**

The system's serial multi-drop PROFIBUS DP redundant ring network shall provide redundant fiber optic cable, and support a maximum cable length of up to 20 Km (for reservoir valves), and use of fiber optic cables there shall be no practical limitation in maximum cable length.

- **Number of H2 Segments per Master**

The system shall support up to 4 redundant PROFIBUS DP (H2) Segments per Profibus Master System. Each pump to be provided separate segments.

- **Number of PROFIBUS Masters per Controller**

It must be possible to connect to a controller up to 4 PROFIBUS DP lines through internal interfaces in the CPU, and up to 10 PROFIBUS DP lines through additional communications processors. On a PROFIBUS DP line it is possible to operate up to 125 devices, and on a bus segment up to 31 devices with PROFIBUS DP interface (32 stations).

- **Online Device (Slave) Addition**

The system shall support online addition of redundant PROFIBUS Slave Devices to a redundant PROFIBUS DP network, even in systems with non-redundant controllers.

- **Direct Support for Control of Motors and Drives**

The system shall support direct support control of motors and drives via redundant PROFIBUS DP without requiring the use of gateways or interposing PLCs.

- **Process Automation Fieldbus Segment (H1)/PROFIBUS PA**

Communication rates with process field devices connected to the H1 field bus shall be 31.25 Kbps. An H1 ring topology should be available such that a disconnect or cut in the ring will still allow communications to all field devices.

- **Interoperability**

The system shall support the use of devices from multiple manufacturers on the same field bus.

- **Interchangeability**

The system shall support the ability for a field device from a given manufacturer to be replaced by one of the same type (e.g. temperature measurement instrument) from a different manufacturer without loss of functionality. The configuration software shall support these features.

- **Number of Devices per H1 Segment**

The H1 field bus segment shall support up to 31 devices in a general purpose area and up to 3 devices in an area. The average current draw per device to be designed by OEM .

- **Minimizing the number of Physical Devices**

To minimize the potential points of failure in the system, no separate physical device connection should be required to provide power to field devices.

- **Integrated Bus Terminator**

The system's H1 interface shall include a power conditioner and an integrated bus terminator to reduce the number of points of failure and to reduce the wiring in the segment.

- **Integrated Barrier for Safe Areas**

The Vendor's gateway to the intrinsically-safe H1 field bus segment shall include built-in intrinsically-safe barriers to connect these types of devices.

6.7 Redundant & Fault Tolerant Process Fieldbus

6.8 To make it practical for users with mission critical applications, the system shall support the creation of redundant / fault tolerant architectures at the H1 level or PROFIBUS Dp.

- **High Availability through fault tolerance**

To allow mission critical process instrumentation to keep running in the event of communication faults, the system shall be able to sustain the following types of faults without interruption:

- Breakdown of the field bus Coupler
- Short circuit or wire break on the field bus backbone
- Short circuit or wire break on a field bus spur segment
- Loss of / Missing terminator

- **Field Device Distribution Box**

To easy installation and maintenance, the system shall support the use of field distribution boxes for connection and termination of multiple smart field devices. The field distribution boxes shall provide the following capabilities:

- Automatic monitoring of trunk line with indication.
- Support connection of at least 4 instruments in redundant ring network.
- Automatic bus termination
- IP67 case, PG connectors
- Short-circuit proof spurs

- Temp. range: -5° to 60° C

➢ **Online Configurability**

The system shall support the making of online configuration changes such as repairs, extensions and modifications to trunk lines.

6.9 Process Automation Fieldbus Segment (H1)/Foundation Fieldbus (FF)

The vendor shall be able to integrate field devices connected via redundant fault tolerant FOUNDATION Fieldbus into the control system architecture.

The System shall have an interface that allows the user to connect FF devices to the system. The following functions should be supported:

- Cyclic and acyclic data exchange
- Diagnostics
- Integration in the systems maintenance station
- "Control In The Field"

➢ **EIB Instabus I/O**

The system shall support EIB Instabus inputs and outputs, as used in building automation systems, allowing the building control system and the plant control system to be combined into one. The EIB interface shall be a link module on PROFIBUS communicating with the devices over the EIB serial cable.

6.10 Communications and Networking

The system shall utilize Industrial Ethernet on the System Bus for communication between controllers and HMI servers or single stations.

The system shall support the use of standard commercial, off-the-shelf networking components for the terminal bus to communicate between servers and clients.

The system shall support the use of Fiber Optic media.

The system shall support communication at 100 Mbps on the system bus and up to 1000Mbps on the terminal bus network.

A project-spanning network view must be available.

Intelligent field devices (Profibus DP, PA, HART, FF) shall be accessible via an integrated configuration tool.

The system shall be able to control and diagnose intelligent drives via the field bus

The system shall support WLAN fiber optic, telemetry cable, UHF & Mirco wave radio wireless networks.

The following maximum network sizes shall be supported: Fiber Optic – up to 150 km, WAN – worldwide (incl. Web-client).

The vendor system should offer networking options and support hybrid applications and linking of package units.

- **Supported Architectures**

The system shall support the following networking topologies for setup of the System Bus: Ring, and Redundant.

The system shall support the following networking topologies for setup of the Terminal Bus: Ring and Redundant.

- **Event-Driven Communication**

To minimize the communication load on the System Bus, change-based communication shall be used by the system for the communication of alarms and events as well as for the communication of process data from the control system to the Operator Interface.

6.11 I/O Bus Redundancy

It must be possible to configure a redundant I/O bus.

The vendor shall provide coupler redundancy.

The vendor must provide a redundant ring structure of the I/O busses.

It must be possible to perform value acquisition from field devices as fail-safe and fault-tolerant, the vendor must ensure this with his bus architecture.

- **I/O Bus Properties**

The I/O bus must have the following properties:

- Avoids unplanned plant down-time with increased availability
- Automatic bus termination
- Detailed diagnostic options
- Changes to the configuration can be performed online. The also takes into account repairs and add-ons including changes on the cable bus.

System Configuration - General

This section specifies the engineering workstation and software tools that shall be available for the initial engineering, configuration, and long-term maintenance of the system.

7.1 General requirements

The engineering workstations shall employ standard PC technology with state-of-the-art hardware based on a Windows operating system, and industrial Ethernet communications.

It shall be possible to install more than one engineering workstation in a system.

The engineering system shall be an open system allowing, for example, project data from Microsoft Excel or CAD/CAE tools to be imported. It must be possible to import/export messages to/from Excel and Access for simple manipulation.

Removable storage media shall be provided at each engineering workstation.

It shall be possible to save all database and configuration data on both removable and non-removable media for back up purposes without taking the system off-line.

It shall be possible to provide redundant storage media for configuration database.

The engineering software shall employ an intuitive MS Windows explorer style interface, which will allow the user to manage all aspects of the controller, HMI, network, hardware, and field device configuration. The use of differing, inconsistent user interfaces should be avoided as much as possible.

The system shall offer fast compile and download times.

The system must support archive marking for variables. Marked variables must automatically be archived.

The system must enable data communication with a CAx system. Support of engineering workflow is required.

The HMI level must be derived from the project created on the engineering station, automatically, to avoid duplicate input of information.

Multi-layer technology must be available for picture designing to enable clear engineering.

The system must enable direct derivation of a picture tree in the OS from the technological/plant hierarchy.

The system shall support hierarchical CFC charts with graphical block type (chart in chart with compilation).

The system shall be able to detect errors in the configuration, test the connection between two different data types and reject them when applicable.

It must be possible to handle the system engineering even without in-depth knowledge of object-oriented programming.

It must be possible to automatically place and connect all process objects.

The vendor system must be able to display a sequential chart in the OS.

Block programming sources must be accessible to users.

The system must harmonize with SQL, SYBASE, X Window and TCP/IP.

Centralized engineering for all components including field devices must be possible.

7.2 Functions of the Central Engineering Workstation

Only one engineering workstation shall be necessary to perform all traditional configuration tasks (Control, HMI, and History), Fieldbus configuration (transmitters, drives, analyzers etc), database generation, and editing. However, it shall also be possible to use multiple engineering workstations simultaneously for this work.

The central engineering workstation shall be capable of supporting all of the following functions:

- I/O configuration
- DCS hardware configuration (controller, operator stations)
- Configuration of plant and field communication networks
- Field bus instrument configuration and maintenance
- Configuration of drives, weighing scales and motor management equipment
- Configuration of continuous and sequential control operations
- Configuration of the plant process structure / hierarchy.
- Configuration of fail-safe Functions
- HMI Graphics display generation and modification
- Tag logging (archive) configuration
- Configuration of historical and real-time trends
- Management of alarm and event configuration
- Report creation, generation and modification

- Configuration of user security and access privileges
- Process object view with test mode
- The operator shall be able to perform their desired picture assembly online.
- Batch Configuration & Planning (Recipes, Procedures, Formulas etc)
- Asset Management configuration
- Access to external files and programs such as Excel
- System Diagnostics
- Servers, Clients and keyboard plant area assignments
- A controller simulator tool to enable logic debugging and testing w/o requiring any hardware.
- It should be possible to protect the engineering project via a user specific password.

7.3 Object Oriented Engineering Tools

Object-oriented configuration tools shall be provided to aid in system configuration. It shall be possible to configure both control and HMI aspects at the same time from this tool for one or multiple process objects. The tool shall include a spreadsheet style interface for configuration which supports ease-of-use with functions such as copy/paste, search and replace, sort by column, and connection with Excel/Access. The following parameters shall be configurable from this interface:

- Control: Loop identifier, Alarm limits, Tuning constants, Descriptors, Engineering Units, I/O assignment.

- HMI: Alarm Priorities, Alarm Message Text, HMI Symbol assignment, tag Archive rates.

The engineering system shall have a uniform database ensuring that data, which has been entered once by the user, shall be available to all tools throughout the system, thus ensuring that there is a single point of entry for the system database.

7.4 Optimization of the Run Sequence

The system shall be capable of naming processing cycles or runtime groups for optimization of the run sequence / runtime group.

It must be possible to change the processing sequence of the function blocks.

7.5 Bulk Engineering Capabilities

The system shall provide tools for bulk editing of the configuration and to facilitate easy duplication of standard control elements (those provided standard by the system or created custom by the user). The duplication tool shall support generation of instance-specific copies via an export / copy / import routine that utilizes a spread-sheet style tool for configuration. Duplication and instantiation of the following element types shall be supported:

- Function Blocks
- Function Block Charts (Control Modules)
- An entire Unit of Equipment
- An entire Process Area
- SFCs

The tool shall support cloning of process control elements through the import of configuration data from an external file.

The tool shall also provide a menu-guided process for defining reproducible elements and for selecting instance-specific attributes (such as tag name or configuration area) of each individual element.

A user interface similar to a spreadsheet shall be provided for cloning elements (such as motors, valves and PID controllers) and for the configuration of their instance-specific properties.

7.6 Standard Process Automation Library for Controller and HMI

A library of standard prebuilt control algorithms for process control shall be available along with their associated HMI faceplates/symbols. Optional

Industry specific libraries shall be available. The standard library shall consist of the control strategies and pre-engineered symbols/faceplates.

7.7 Configuration Structure

The application shall be viewable and configurable in a hierarchy which groups configuration elements according to the plant or process structure. This plant hierarchy shall be capable of directly representing the process model and the physical layout of the process. It shall be used to automatically derive the display hierarchy in the operator interface and to generate the dynamic elements of process graphics.

For maximum flexibility in structuring the controller program, the system shall support the creation of a configuration hierarchy that is at least eight levels deep.

7.8 Copy / Paste

The system shall support *copy and paste* of all configuration elements contained within the hierarchical configuration structure including:

- Control Modules (Function Blocks or Charts)
- SFCs
- Process Graphics

The system shall support the ability to copy and paste multiple levels of the hierarchy in a single step (Deep Copy) allowing entire process areas or units to be copied and modified with minimal engineering effort.

7.9 Concurrent Engineering

The system shall support concurrent engineering practices whereby multiple engineers can work on the same application via a networked environment or via a "check-in / check-out" style for configuration locally on different PCs.

7.10 Documenting the Configuration

Tools shall be available for automatically documenting the configuration and project data.

The system shall be able to display the connections between individual charts in the automatic documentation.

7.11 Online Configuration Changes

The system shall support making changes to the controller, I/O, HMI, and Communication network while online without interrupting operations.

7.12 Change Management (General)

The engineering station (ES) shall support versioning.

Configuration additions, changes, and deletions shall automatically update all modules and tags affected by the change.

Configuration changes shall follow a prompt-validation sequence requiring a final acknowledgment step before the change is downloaded to the on-line system. An option shall be provided to allow the user to view a detailed report of changes as part of the download confirmation process.

When configuration data are compiled or downloaded to the system, invalid configuration entries shall be identified and the parameters affected shall be indicated.

In the multi-project mode, the system shall support updating of blocks from the master data library in libraries of the individual projects.

7.13 Multilingual Engineering Environment

At a minimum, the English, languages shall be supported by a single version of software. The user shall be able to toggle between the different supported languages in the Engineering and Operator runtime environment without having to recompile the program.

8.0 Configuration of Control Strategy:-

8.1 Choice of Configuration Languages:-

Configuration languages shall be offered that are traditionally associated DCS programming environment. These shall include the following programming languages including those described in standard IEC 61131:

- Continuous Function Charts (CFC)
- Sequential Function Charts (SFC)
- Structured Control Language (SCL)
- Relay Ladder Logic (LAD)
- Instruction List (STL)
- Function Block Diagram (FBD)

8.2 Sequential Function Chart (SFC)

A sequential function chart (SFC) tool shall be available for graphical configuration of sequential and batch processes per IEC 61131-3. Steps and transitions shall be graphically configured using a convenient editing function. The tool shall support comprehensive syntax checking during configuration.

Connections to continuous control functions shall be available using simple actions such as *Browse, Drag and drop* and *Fill in the blanks*.

The operator's visualization display shall be automatically created, including dynamic step/transition boxes, overview, navigation display, and list boxes.

To minimize configuration time, the system shall automatically connect SFC steps and transitions during configuration, based on their placement in the SFC chart, without requiring the user to manually connect them.

The SFC tool shall provide a standard interface for configuration of the three phases of execution of a step (Initialization, Execution and Termination).

The vendor system must be able to display multiple SFC groups with their current states in a picture in tabular form.

8.3 Structured Control Language

A structured control language (SCL) shall be available which utilizes a high-level text-based language whose global language definition conforms to IEC 61131-3. This language, which is similar to PASCAL, shall be capable of being used to program calculations, complex optimization algorithms, define HMI attributes / behavior and to call other function blocks directly from within the program. It shall

support the use of a subroutine style of programming to maximize modularity and reuse. Function Blocks created using SCL can be used throughout the program like standard function blocks in the CFC Editor.

8.4 Ladder Logic

The system shall support programming in Ladder Logic using syntax similar to a relay ladder logic circuit diagram. The elements of a circuit diagram can include normally open contacts, normally closed contacts, function blocks etc which can be combined to form networks per IEC 61131-3.

8.5 Instruction List

The system shall support the use of a Statement List Programming Language (STL) which utilizes a structure similar to machine code. Each statement shall represent a program processing operation of the CPU. Multiple statements shall be capable of being linked to form networks IEC 61131-3.

8.6 Function Block

The system shall support configuration using function blocks according to IEC 61131-3.

The user shall be able to modify the appearance and behavior of function blocks by simple modification of an object's property sheet.

Function blocks shall have integrated startup characteristics which govern their behavior during cold start, warm start and hot start conditions.

8.7 Custom Function Blocks

The system shall allow users to create their own custom function blocks from scratch using ladder logic, structured control language or other. These custom function blocks should be able to be added to the application library for reuse throughout the project.

Custom function blocks shall be used in the application just like a standard function block (for example they can be embedded in CFCs or connected to standard function blocks)

Custom function blocks shall have the capability of being password protected so that access to proprietary intellectual property may be protected in the field.

There shall be no practical limit to the number of custom objects that that a user can create and download is only limited by the memory capacity of the target controller.

8.8 Process and Equipment Interlocks

For ease of use and to minimize engineering costs, it shall be possible to configure device interlocks graphically via simple point and click operations between function blocks. It shall not be acceptable to require the user to program the interlocks using a text-based script-editor.

➢ Testing and Commissioning

All configuration tools shall have test and commissioning functions, for example, it shall be possible to display and modify the value of a function block input or output parameter during operation, and with SFCs, to display step conditions and transitions during operation.

From the engineering environment, the user shall be able to create a Dynamic Display List to view and manipulate selected real-time input and output values from the control strategy within a spreadsheet-style view.

The user shall be able to create Dynamic Trend Displays from the engineering environment to monitor selected real-time input and output values from the control strategy.

It shall be possible to disable the execution of a configured module or force specific values (i.e. hardwired I/O signals) to override the actual signal, all without affecting other modules that may be running in the same controller.

8.9 Configuration / Change Management

➢ Change tracking of Function Blocks

Each function block or chart shall have a unique Date/Time stamp which indicates when it was last modified. This information shall be displayable as an object property so that it is viewable directly from the engineering tool.

Function blocks / Charts shall support the assignment of a unique version number and author. This information shall be displayable as an object property so that it is viewable directly from the engineering tool.

➢ Comparison Tool.

An optional tool shall be available to perform a detailed comparison of two applications or versions of an application. This tool shall use a MS Windows Explorer-like interface to graphically highlight what elements of a configuration are different (CFCs, SFCs, Function Block types, Scan Rate Order etc). By selecting a

"flagged" element, the user can dive deeper to determine exactly what is different (such as an Alarm Limit or Tuning Parameter).

The comparison tool should be able to identify differences in the following elements at minimum:

- Application Program (Function Blocks, Charts, SFC, hierarchy / layout)
- Hardware Configuration
- Communication / Network Configuration
- Alarms
- SFC details (Steps, Transitions and Properties)

➢ **Project-Specific Libraries**

The system shall support creation of a project-specific library which contains only those standard function blocks, charts, and custom function blocks developed by the user that have been approved for use on the project. During configuration all other system libraries can be hidden to ensure that the project team uses only the "project-approved" elements during the application development phase.

➢ **Central Management of SFCs**

The system shall support central management of SFCs by providing "SFC Types", which allow a single sequential function chart to be copied and reused throughout an application. Making a change to one instance of the SFC shall result in the automatic update of all other instances in the configuration, thus saving engineering time and minimizing the chance of creating inconsistencies in the application.

➢ **Change Log**

An optional tool shall be available for use on the Engineering workstation to enforce user access control for execution of protected actions (such as downloading a configuration change to the controller) and to allow recording of comments (detailed reason for change). Information will be recorded in a change log file, which shall be continuously updated with each new change. The change log shall be capable of being reviewed at a later point in time.

➢ **Read/Edit Protection of Function Blocks**

The system shall support the locking of user-created custom function blocks. This ensures that the contents of the custom block cannot be viewed or edited, allowing users such as OEMs to securely protect their intellectual property.

8.10 Integrated FDA Functionalities

The vendor shall offer wide-ranging FDA functionalities in his system, including features listed in the following:

- System Logon

- User administration and access control
- Staged permission levels
- Change log: recording of all changes during the production
- Automation system : program download, changes in test mode for CFC/SFC, download of hardware and communication configuration
- OS: program download
- Route control: program download
- Change log: changes in projects and libraries, logons/logoffs, opening and closing projects and libraries, changes to settings
- Version management: versioning of projects, libraries, multi-projects, recipes
- Comparing/updating projects (Version Cross Manager): CFC/SFC, hardware configuration, communication configuration, OS alarms, plant hierarchy, SFC details (step, transitions, properties etc.)

8.11 General

A driver wizard shall be available to generate all blocks required for the diagnostics of I/O modules and field devices.

Object naming shall support at least 16 alphanumeric characters, and users shall be able to change an object's tag name without deleting and re-adding the object or any references to it, for example, SFC charts, process pictures or tag logging archives.

8.12 Database Reporting and Modification Utilities

➢ Global Search Utility

Utilities shall be provided for global searching of the database. These utilities shall be under system access control.

➢ Cross Reference Data Listings

The system shall be capable of generating listings containing the following fields:

- Tag ID
- Tag descriptor
- Point type
- Hardware address

It shall be possible to perform the following functions on the above list:

- Sort alphanumerically by any field
- Filter by any field
- Print, display and store to media
- Export Data

The above listings shall be available for all devices in the system.

9.0 Configuration and Management of Field Devices:-

A field device management tool shall be available to configure, parameterize, commission, and view diagnostics for intelligent field devices remotely (via a local station in the field), or from a central engineering station.

This single tool shall provide a uniform display of device parameters and functions for all supported devices regardless of their communication link, for example PROFIBUS-DP, PROFIBUS-PA, the HART protocol and Foundation Fieldbus H1.

The tool shall support the online addition of field devices to the network without interrupting operation of the system.

The management tool shall support configuration and management of devices from 3rd party manufacturers as well as those from the system vendor.

The system shall offer the option to connect modules that are outside the standard range.

The system shall offer the option to connect fail-safe field bus instruments.

The system offers ready solutions for controlling and diagnosing drives via the field bus.

The vendor system must provide a stable power supply for HART modules.
It must be possible to configure interlocks without a programming language.

9.1 Centralized Engineering, Maintenance & Diagnostics

The field device management tool shall have the capability of communicating with remote field devices from a central location using routing. The routing functionality shall allow communication to pass between different networks or subnets of the system transparently, so that the user can communicate with remote devices without having to connect locally to them in the field.

9.2 Communication modes

The field device management tool shall support the following modes of communication at a minimum:

- PROFIBUS DP Interface
- PROFIBUS PA Interface
- HART Interface
- HART Multiplexer

- HART Modem
- Foundation Fieldbus Interface.

9.3 Functions of the Field Device Management Tool

The tool shall provide the following main functions:

- Assignment / Configuration of Slave (network) addresses
- Device adjustment and modification
- Device comparison
- Plausibility testing
- Simulation, including a choice of predefined simulation routines such as ramp up, down, randomize, etc.
- Automatic diagnostics
- Management and commissioning
- Online monitoring of selected values, alarms, and status signals
- Life list for the automatic detection of existing field devices with the ability to:
  - Open a device configuration screen directly from the life list
  - Add devices from the life list to the application
  - Configuration of field instrumentation from the life list (for field bus and for HART devices)
- The vendor system shall support HART instruments in the life list
- Import/Export capability for field device data exchange with other projects or other tools.
- Export of device status information
- Document management to allow online access to up to 10 documents per device
- Change log

9.4 Field Device Management Displays

The tool shall have a graphical user interface supporting several different views of the field devices:

- Hardware project view

- Process device network view – Displays device information, including diagnostic status, grouped according to the network topology
- Process device plant view – Displays device information, including diagnostic status, for all devices in the system from all configured networks
- Field device parameter view – Displays detailed device parameter information in a tabular format. This view shall support display of the following parameter information: Parameter Name, Value, Unit, and Status (Initial Value, Changed, or Invalid)

➢ **Comparison of Online and Offline Device Data**

The tool shall support the ability to do a direct comparison of the online and offline device data. The comparison shall be displayed in a side-by-side format with the differences highlighted automatically by the tool.

➢ **Updating Device Profiles and Adding New Devices**

The device management tool shall support the easy integration of new field devices and device driver updates of existing devices purchased from the system manufacturer or from 3rd party manufacturers. The device description files and drivers required for updating the management tool can be downloaded from the manufacturer's internet site. Device description files will utilize the Electronic Device Description Language (EDDL) format.

➢ **Device Diagnostic States**

The management tool shall support the determination and display of the following diagnostic states at a minimum:

Communication States: Unchecked, Fault, Good

Device Status: Unchecked, Configuration Error, Fault, Maintenance Required, Maintenance Recommended, Simulation or Manual Operation, Process Error, Good

➢ **Role-based User Access & Security**

The tool shall provide at least two different sets of user access and authorization privileges. At minimum the following users and sets of access privileges shall be provided

Maintenance Engineer – Can modify only operational data (parameter changes)

Specialist - Can modify all configurable data. Includes the optional definition of a password for access protection

➢ **Logging Tool**

For troubleshooting purposes, the device management tool shall provide an integrated logging function. The log shall provide the ability to activate and choose which types of messages are displayed within the tool and to be saved to file for later review.

The following types of messages (selectable) shall be recorded as part of the logging function:

- Errors
- Warnings
- Communication Messages

9.5 Configuration of the Operator Interface:-

The workstation for Human Machine Interface (HMI) shall provide an object-based process graphics engine, which is capable of providing process visualization and control. A standard utility shall be provided that is able to generate and modify user-defined color graphics. It shall use the same tag IDs that are used in the process database to access real-time variables from any database. It shall be subject to system access protection.

The vendor system shall offer a wireless, mobile input medium.

The number of simultaneously opened windows may not be limited.

9.6 Standard Graphic Elements provided by the System

Standard graphic elements provided by the system should include but not be limited to: Lines, polygon curves, polylines, circles, arcs, ellipses, rectangles, polygons, static text, OLE objects, ActiveX objects, input and output fields, bars, graphic picture objects (bitmap BMP, Windows Meta

File WMF, and Enhanced Windows Meta File EMF), status displays, text lists, 3D bars, buttons, check boxes, radio boxes, and sliders.

The system shall provide pre-configured smart control objects to represent clocks, gauges, tables, application windows, alarm windows, and trend windows.

The workstation shall be supplied with a full library of process-oriented objects for the development of process graphics including but not limited to: pipes, motors, valves, pumps, tanks, fans, indicators, sensors, conveyors, and electrical symbols. These objects shall be provided in various formats (static, capable of being dynamically linked to the control strategy, 2-D, and 3-D).

9.7 Dynamic HMI Symbols for the Control Library

Pre-engineered graphics symbols shall be provided for all process control elements in the standard control library (PID Controller, Valves, Motors, etc). These pre-engineered symbols shall be designed to call up their associated faceplate and to represent the dynamic behaviors of the underlying control element, without requiring any additional configuration effort.

The workstation shall allow the user to create libraries of custom and composite symbols. Library management shall be an integral part of the system.

The system shall allow identical handling of all safety- and non-safety-related process tags (process variables) in the OS (visualization, operator control, monitoring, etc.).

9.8 Global HMI Symbols

The system shall support the creation of global HMI symbols for representation of process control elements. Edits to one instance of a global symbol shall be propagated automatically via a wizard to all other instances of the symbol in the application without manual reconfiguration.

HMI Faceplates

Faceplates shall be generated automatically by the system for each function block / chart provided in the process control library (PID Controller, Motor etc).

The User shall not be required to individually configure a faceplate detail display for each instance of a process object or control module.

Faceplates shall be linked to a corresponding HMI symbol such as a motor or valve. The symbol shall be programmed automatically by the system to call-up the appropriate faceplate without requiring any manual engineering steps.

A Faceplate list (Tag List) shall be created automatically by the system. This tag list will allow an operator to call up a faceplate by selecting it from a list of tag names.

The system shall provide a dedicated Faceplate Designer utility to facilitate easy creation of custom faceplates.

It must be possible to simultaneously open 3 faceplate instances on the OS (operator station).

9.9 SFC Visualization

To minimize engineering costs, the system shall be capable of automatically generating HMI representations of SFCs (aka SFC Visualization) directly from the control strategy, without additional engineering. These screens shall allow operators to monitor the status and interact with an SFC directly from an operator console.

9.10 SFC Status Displays

The system shall provide a standard SFC Status display object which will provide an overview of the status of the area-relevant SFCs. Additional information including the SFC Visualization faceplate shall be accessible from this status display.

9.11 Automatic Creation of Process Graphics

HMI displays, including the dynamic elements used to represent function blocks (such as motors, valves and PID Controllers), shall be generated automatically from the controller configuration. No manual engineering shall be required to place the dynamic elements on the displays or to link them to the controller configuration.

The user interface should support automatic creation of static process pictures with MS Excel and Visual Basic.

9.12 Automatic Creation of Display Navigation

A hierarchical navigation scheme (similar to folders in Windows Explorer) shall be created automatically by the system for operator call-up of process pictures.

9.13 Change Management

To simplify change management and limit configuration errors to a minimum, the system must support automatic updating of all references to changes (Change Management) in a function block (including process graphics, faceplates, archives and scripts), for example, by changing the instance name of the function block.

9.14 HMI Scripting

The HMI development environment shall support the ability to customize the application through the use of powerful scripting languages. The system shall support the following languages

- ANSI C
- Visual Basic Script (VBS)
- Visual Basic for Applications (VBA)

The programming environment shall support the following functions:

- Ability to access properties and methods of all Active-X controls included with the application or provided by a 3rd party
- Ability to easily establish connections to other applications / databases (such as Microsoft Excel and SQL databases)
- To execute system functions such as initiating a report or generating an operator message
- To define custom menu entries or configuration dialogs
- User friendly editor with debugging support

- Search and replace function to facilitate text modifications
- A windows tree / list view presentation techniques to facilitate the display, creation, and editing of program scripts
- Ability to have multiple functions or actions open simultaneously, and be able to drag and drop code between them

The programming environment shall permit user developed functions and/or libraries to be easily loaded and called.

9.15 HMI Database

The system shall have the flexibility for the user to configure how many levels of the controller structure (up to five) should be included in the HMI tag name.

The database system shall support both internal (computational) and external tags (real world). The database system shall support the following tag types/storage formats: binary, signed 8-bit, unsigned 8-bit, signed 16-bit, unsigned 16-bit, signed 32-bit, unsigned 32-bit, 32-bit IEEE 754 floating point, 64-bit IEEE 754 floating point, 8-bit character text, 16-bit character text, raw (user definable) and structured (template) tags.

Tag IDs shall be unique throughout the system and access to all tag parameters for configuration shall be available directly by tag ID.

The system shall provide the capability to define free-format alphanumeric descriptors for each state of a multi-state device, for example, open, closed, travel, and fault for a motor operated valve (MOV).

Configuration and archive data shall be stored in a relational database, which can be read using ODBC (open database connectivity) and Standard Query Language (SQL).

The vendor system shall provide consistent archives following a system failure.

The project archive shall contain all HMI segments. Additional work steps are not accepted.

9.16 HMI Text Library

To support localization of multilingual applications the system shall provide a text library of terminology which can be configured to contain translations for any number of languages defined by the user. This text library shall be accessible by the operator interface during runtime to allow messages and text strings to be presented in the local language. The text library shall be capable of being exported and imported to facilitate easy configuration using Microsoft Excel®.

10. Operator Interface Architecture and Hardware

10.1 Architecture

The Operator Interface shall be flexible to cover all possible applications from single user system (single station) to distributed client / server architectures. The architecture shall promote the use of multiple server and multiple client configurations.

The system shall be scalable, enabling the user to expand an existing installation by a simple license upgrade.

The system shall allow multiple clients to access up to 12 servers or 12 redundant pairs of servers. Each server or pair of servers shall be able to communicate with up to 32 clients.

Any server computer shall be able to be dedicated to specific process functionality (i.e. Alarm Service, Historical Data Collection, etc.)

Archiving of process variables should be possible on single stations, OS Servers and a dedicated Central Archive Server.

In general it should be possible to add a redundant OS Server or Central Archive Server to a non redundant structure at any time.

All clients shall have complete visibility to all servers and the central archive server, and all servers shall have visibility at the peer level.

The software shall promote portability of applications between computers without any redevelopment or modification.

It shall be possible for the user to monitor and control the process from client or server. This includes but is not limited to:

- View the same or different displays simultaneously
- Make process adjustments and acknowledge alarms
- View alarms, events, trends, and reports

The development and runtime environments shall be decoupled allowing the user to configure run-time only clients without any development capabilities.

For small systems it should be possible to combine all system engineering functions, the Operator Interface, Archiving, Batch and Controller on one PC.

10.2 PC Platforms

The Operator Interface consoles shall utilize standard PC technology with state-of-the-art hardware based on a Windows operating system, and industrial Ethernet communications.

The system shall support the Window operating systems Windows 2000/XP/2003, vista and latest edition.

It shall be possible to swap out the complete project data onto external disks for long-term data storage.

10.3 Monitors

Monitors for operator stations shall be as follows or better:

- Diagonal measurement 21 inches nominal
- 1280 x 1024 resolution
- 32,000 colors

10.4 Multi Monitor operation

The system shall support quad graphics cards with a resolution of up to 1600x1200 pixels and latest

If multi-VGA cards are used, each OS client shall be able to drive between two to four monitors, but with a corresponding reduction in the number of clients per server. The multi-monitor workstation shall allow user configurable layouts. It shall be possible to dedicate either one or both monitors to the operator interface. Additionally, it shall be possible to use the second monitor to view other applications without interfering with the viewing of operator process graphics and displays.

10.5 Printers

- **Display Hardcopy**

The OS shall be able to generate a hardcopy of any active display.

The system shall support both full color and black and white copies for all displays.

The system shall support local or networked printers.

Laser printers shall be supported.

10.6 Time Synchronization with Control System

The Operator Interface shall be capable of synchronizing its time with the control system so that there is no more than a 3 msec deviation between input/output events in the field and events occurring and being time stamped at the HMI level.
System time will be based on UTC. However means shall be provided to display time based on the local time zone setting within the Windows Operating System.

The System shall support connection to a highly accurate time source such as GPS (Global Positioning System) or DCF77 which can be used as the time master for the system.

Date and time synchronization shall be possible anywhere in the world using a satellite source such as GPS (Global Positioning System).

10.7 Web / Thin Client HMI Architecture

The system shall support web-based HMI functionality from an Internet Explorer Browser window via an Intranet/Internet or TCP/IP connection to the system's HMI Web server.

HMI Web Server

The HMI Web server shall be capable of supporting access for web clients simultaneously.

HMI Web Client

Web Clients shall not require a full installation of HMI software, but should be operational simply by loading Internet Explorer in combination with selected plug-ins. Plug-ins shall be loadable over the internet.

Creating HMI Displays for Web /Thin Client Operation

HMI graphics for display on a Web client shall be automatically created by "publication" of the application into a form suitable for presentation by Internet Explorer.

Web / Thin Client Operation

The Web client will utilize operator graphics similar to those on the main control system with access privileges based on security/login information used in the main control system. Based on password access, web client users will be able to perform the following standard operator actions at a minimum:

- setpoint changes
- automatic/manual loop status changes
- alarm acknowledgement.

Security of the main Operator Station Web server is maintained by end user limiting access by firewall and password authorization to their plant/corporate network.

11 Operator Interface for Process Control and Monitoring (Runtime)

11.1 General

All displays and graphics that show real time data shall be automatically updated when the display or graphic is on a screen. Updates shall not require operator initiation.

Operators shall be able to easily access specific displays and graphics by pressing dedicated function keys or overview buttons, selecting from a hierarchical list of displays in directories or menus, or by selecting from an alphabetical listing of all displays.

It shall be possible to move between related displays and graphics of different detail levels or of the same detail level with a maximum of two operator actions.

Special indication shall be used to indicate that a value is invalid.

The system shall provide an overview of the alarm status of all areas to which the operator has access, no matter which graphic is displayed.

The vendor system must provide information regarding the violation of performance limits (memory, cycle time) during download.

It must be possible to modify operation enable for each instance (relating to parameter type).

The system shall allow plant operation and data communication via the Intranet/Internet (use of Internet browsers) based on the configuration.

11.2 Graphics Subsystem

The graphics subsystem shall allow the operator to trigger a control action based on one or two user inputs. At a minimum, the control action will be triggered upon:

- Mouse button press
- Mouse button release
- Keystroke event

The operator shall enter data by either:

- Direct data entry
- Use of up/down keys
- A scrollbar or slider

The operator can browse in the picture hierarchy at the top of the screen to bring up the desired display.

User configurable buttons or screen targets to select operational functions or displays with a single entry shall be provided. Popup displays shall be movable and expandable by the operator.

All operator triggered control actions shall be logged within the message archive system.

It shall be possible to change control assignments to allow control of any plant area from any operator workstation by using the appropriate access password.

An SFC visualization display shall be available showing the step and transition displays with step comments or the dynamic step conditions.

11.3 Faceplates

Faceplates shall be provided with the system to allow for control and monitoring of both regulatory and discrete control algorithms.

Faceplates shall support the display of the following information as applicable:

- Tag ID.
- Tag descriptor.
- Process input, setpoint, and output values displayed numerically with engineering units.
- Process input, setpoint, and output in bar graph representation.
- Auto/manual mode and remote/local setpoint status.
- Visual indication for alarm status.
- Symbolic and alphanumeric indication of discrete states both for two state devices and multi-state devices.

Faceplates shall be defined to pop-up when the appropriate location on a process graphic (such as a symbol) is selected with the mouse.

➢ **Regulatory Control**

Faceplates shall show dynamic process and status information about a single control loop. It shall be possible to perform the following control actions from a faceplate:

- Change control block mode.
- Change setpoint and other operator settable parameters.
- Adjust outputs in manual mode

- **Discrete Control**

Single faceplates shall be provided for control and indication of multi-state devices. For example, a motor operated valve shall indicate open, closed, intermediate position, and fault. An operator shall be able to operate the device (start, stop, open, close) from the faceplate.

11.4 Process Graphic Displays

It shall be possible to place a new graphic in service without interrupting an operator's ability to control the plant.

All control, monitoring, and status attributes of any tag shall be displayable on graphics. For analog points this requirement includes measurement, setpoint, alarm limits, and output. For digital points this requirement includes input and output status. Status information includes: alarm status, control mode, and control status.

Numeric data shall be configurable on an individual basis. If the decimal point is not used, it shall be suppressed.

It shall be possible for each state of a multi-state device to be indicated by a unique foreground/background color combination.

It shall be possible for inactive alarm or status messages to be invisible to the operator.

Symbolic representation of data on the graphics shall be performed by color changes (foreground and background independently), and flashing in any combination.

The system shall support programming of tooltips which will display a configurable text message to an operator when he hovers over the element with his mouse.

It shall be possible to configure an area on the screen that calls up other displays.

It shall be possible for the operator to zoom in and out during runtime.

11.5 Screen Composition Favorites

The system shall support the operator’s ability to save specific screen compositions or layouts for call up at a future time. A favorite screen composition can consist of a process graphic with any number of specific device faceplates, trends etc. overlaid on the screen and positioned in specific locations of the display.

11.6 Security

The system must permit following virus scanners compatible to MS Windows on the real-time computers:

- Trend Micro "Office Scan" Corporate Edition V7.3 or latest version

- Symantec AntiVirus Corporate Edition V9.0 (Norton Antivirus) or latest version
- McAfee VirusScan Enterprise V8.0 or latest version.

The system security shall be modeled after Windows XP but configurable in a manner appropriate for control operations.

The system security configuration tool shall provide an easy to use, simple interface, which offers full support for standard Windows techniques such as copy, cut and paste, as well as drag and drop.

The system shall allow an individual's authorization to be programmatically modified and/or verified as part of the Control Logic/Scripting requirements.

The system security shall allow the configuration of authorization groups whereby individual users can be assigned to permission groups.

The system security shall allow the configuration of process area specific security for up to 256 different process areas.

The system shall support the configuration of custom security and access authorization levels up to a total of 999.

➢ **Default Security Levels**

The OS system security shall provide different security levels to allow the access and interaction with the process to be controlled. At a minimum the following access levels should be pre-defined:

- User Administration
- Ability to View alarms and call-up Displays from a particular area of the plant
- Ability to Navigate through the system
- Process Monitor - Ability to view the process in Monitor Only mode
- Process Control (Basic) - Ability to Control the Process by sending commands, acknowledging alarms and changing setpoints etc.
- Process Control (Advanced) - Ability to modify alarm limits, PID tuning coefficients etc.
- Ability to trigger reports

- Ability to control archiving / storage

➢ **Advanced Access Control**

The Operator Interface shall support the optional use of a chip card readers or a fingerprint mouse (biometric signature) to ensure unique user identification.

➢ **Global Security**

The system shall support an optional common security system whereby the same login / password is used for the Windows operating system, the engineering environment, the HMI and for the Batch system.

11.7 Expandability and Extensibility

The system shall be able to collect data from multiple data servers, including other OPC-enabled process and control systems.

It shall be possible to exchange system data with other third party software that are compatible with the Microsoft operating system.

The OS system shall be based on an open architecture and support extensibility thorough the use of:

- COM/DCOM
- ODBC (Open Database Connectivity)
- OCX / ActiveX Controls
- OLE (Object Linking and Embedding)
- OPC (OLE for Process Control) Data Access Protocol (DA)
- OPC Historical Data Access Protocol (HDA)
- OPC Alarms & Events Protocol (AE)
- OPC Historical Alarms & Events (HAE)

The OS system functionality shall be expandable via the optional add-ons including, but not limited to:

- User programmed ActiveX objects
- Automatic event driven email messaging of real-time information
- Event triggered display of live process images
- Long term historical media-based data storage
- Configurable messenger functions such as SMS, E-mail, Pager

12 Alarms, Events, and Messages

12.1 General

The alarm system shall provide complete alarm and event management with a user definable message structure.

The alarm system shall support definition of up to 16 message sub-classes and 16 message types.

Alarms must be assigned a time stamp based on the execution cycle in the controller.

The vendor system shall support a time stamp resolution of 1 ms for binary inputs.

The alarm system shall alarm any change of state that the system detects including:

- Any violation of limits
- Any change of state of a device connected to the system including all of its peripherals
- The failure of any communications channel used by the system
- The failure of system's hardware, which results in an automatic fail-over of the system's functions from the active to standby device.

The alarm system shall display alarm messages in a manner to facilitate easy interpretation of the current alarm status including but not limited to:

- Different text color and background color for those points that are in alarm, those that have been acknowledged, and those that are no longer in alarm
- Flashing of the current alarm message(s) in the alarm list
- Alarms that have been automatically hidden by the system or manually by the operator
- The system shall provide the option of displaying alarms in ascending or descending temporal order.

The vendor system shall provide a configurable, OS-spanning horn design.

The vendor system shall provide automatic alarm in the plant overview, without additional configuration.

The vendor system shall support more than 4 alarm priorities and more than 5 permission levels.

Alarm Acknowledgement

The alarm system shall provide capability to acknowledge an alarm message when a data point enters and / or exits alarm state. The system shall permit alarm acknowledgement including but not limited to:

- For an individual alarm from the overview
- For a filtered grouping of alarms from a summary list
- From the device faceplate
- From a process display (screen acknowledge)

Alarm acknowledgement from one operator station shall be automatically synchronized to other stations to provide global acknowledgement capability.

The operator name shall be saved when alarms are acknowledged.

The system shall offer the option to disable or enable messages via a second set of keys.

Filtering of Alarms

The alarm system shall provide filtering to control the behavior of the alarm display screens. The filtering attributes shall include but not be limited to:

- Date
- Time
- Alarm class
- Alarm type
- Alarm priority
- Status (in alarm, out of alarm, or acknowledged)
- Tag name
- Area

Alarm Status Symbols

The alarm system shall provide the ability to condense and present system alarming status in the form of a standard alarm status symbol (i.e. alarm group display). The group display shall be capable of indicating the status of an individual device or of an entire process area. When used to represent the status of a process area, the group display shall form a logical *OR'ing* together of the alarm states from all devices in the process area.

The group display shall include the following standard alarm categories at minimum, which will each be represented in the symbol with a different color and text representation:

- Alarm
- Warning
- System alarm

- Operator message (operator action required)
- Suppressed alarm state

12.2 Alarm Priorities

To allow for segregation of alarms based on criticality, the system shall support the assignment of individual alarm conditions to one of at least 16 different alarm priorities.

12.3 Categorizing Alarms and Messages

Process and designated system alarms shall be annunciated, displayed and stored in history files. Normal plant operator actions, events and normal system actions and events shall not be alarmed; however, they shall be stored in centralized history files.

Alarms and messages shall be grouped to allow the user to readily identify and respond to alarms and conditions (e.g., in priority sequence) in his area of responsibility.

For any process alarm, it shall be possible, by no more than one operator action, for an operator to access a display from which he may take corrective action.

The system shall support the ability to display the highest priority, most recent, alarm at all times.

Operator Actions

The system shall automatically store all operator actions that affect process control parameters or alarm acknowledgment in centralized history files, including:

- Enable/disable/acknowledge/suppress/lock/shelve alarms
- Change mode of controllers
- Change setpoint of controllers
- Changes to alarm limits.
- Changes to tuning parameters

Engineer Actions

The system shall provide the ability for Engineering actions that change the control and monitoring of the process to be stored in a log file along with a comment. These actions shall include the following:

- Download of controller configuration

- Online/Test Mode
- Download of Operator Station Configuration

12.4 Process Alarm Initiation

It shall be possible to initiate process alarms by configuring alarm attributes of any process I/O point or any calculated point.

For analog tags, the configurable triggers for process alarms shall include:

- Process variable high limit exceeded
- Process variable high high limit exceeded
- Process variable low limit exceeded
- Process variable low low limit exceeded
- Process variable deviation from setpoint
- Process variable invalid value (bad quality)

For digital tags, the configurable triggers for process alarms shall include

- specific state (0 or 1)

Alarm Suppression / Disablement

The system shall provide the ability to disable or suppress alarms at the following levels:

- For each individual alarm condition
- For all alarm conditions associated with a device or point
- For all alarm conditions associated with an alarm group, process area or displayed on a process graphic

12.5 Minimizing Nuisance Alarms

To minimize the occurrence and effect of nuisance alarms on an operator, the system shall provide the following capabilities for identifying, managing and preventing them.

Alarm Deadbands & Chatter Suppression

To minimize analog input *chattering* (a point going in and out of an alarm condition rapidly) there shall be configurable dead band parameters, on an individual tag basis.

To minimize the occurrence of nuisance alarms during startup / shutdown scenarios the system shall support alarm chatter suppression at the controller level. This feature shall ensure that alarms are not retriggered at the HMI until they have been acknowledged.

HMI Displays for Identifying Nuisance Alarms

To help plant personnel identify nuisance alarms, the system shall provide standard capability to perform and display an alarm frequency analysis which identifies those alarms that have occurred most frequently over a given period of time.

12.6 System Alarm Initiation

Failures of individual components of the system shall result in the generation of an alarm message. A system alarm shall be generated in the event of a failure for the following components at minimum:

- Field device
- Individual I/O channel
- I/O module
- I/O rack
- Communication modules (bus and network)
- Power supplies
- Communication network
- Controller
- Server/clients
- Central archive server
- Time synchronization

All devices connected to the system communication network shall be monitored for failures. A system alarm shall be generated for each failure detected.

12.7 Process and System Alarms History Retention

All alarms shall be stored in history files with the capability to archive these to removable media. Capability shall be provided to recall these alarms in visible display lists and printed lists according to selectable filtering options.

12.8 Alarm Annunciation

The system shall be capable of annunciating process and system alarms in ways including but not limited to:

- Activation of an external audible alarm or light

- Activation of the internal PC sound card (playing of .wav files)
- Updating an alarm display with the current alarm
- Updating an alarm overview screen to indicate the occurrence of an alarm in a specific process area / display
- Printing the alarm message on an alarm printer
- Any graphic object associated with the alarm point will change color, shape, appear, disappear, etc. as configured.

Audible Alarm Annunciation

All alarms for a process area may be assigned to any operator station at configuration time. All alarms shall be displayed on the operator station(s) designated. The audible alarm system shall be user configurable for different tones or patterns. A unique tone or pattern shall be capable of being generated based on alarm priority, message class or process area.

The system shall use global alarm acknowledgement allowing a single acknowledgement from any workstation to acknowledge that alarm on all stations and to silence the audible alarm.

Visible Alarm Annunciation

Alarms shall cause visible display annunciation at, and only at, an operator station configured for those alarms. The annunciation shall occur within 3 seconds of detecting the initiating event. It shall be possible to acknowledge process alarms only from an operator station configured for those alarms. It shall be possible for an operator to acknowledge any alarm configured at his station by no more than two actions.

12.9 Alarm Summary Display Lists

The system shall provide the following alarm summary display list capability at a minimum:

- Active Process Alarms
- Cleared Process Alarms
- Acknowledged Process Alarms
- Active System Alarms
- Cleared System Alarms
- Acknowledged System Alarms
- Journal (Alarm History)

- Operator Action List
- Suppressed (Locked) Alarm List
- Shelved (Hidden) Alarm List
- Alarm Frequency Display (Hit) List

Accessing an alarm summary display from any other display shall require no more than one operator action.

Visible display of any alarm shall not clear unless the alarm is acknowledged; and the item initiating the alarm has returned to normal condition.

Multi-page displays may be used. If so, it shall be possible to page forward or backward by a single operator action. The display shall list alarms in tabular format in order of occurrence with the most recent at the top.
It shall be possible to assign alarms to separate areas of the plant so that arriving alarms are entered in area message lists to create an area-related view.

12.10 "Smart" Alarming / Alarm Hiding

To minimize the alarm load on the operator and the presentation of alarms which are meaningless in context, the system shall support "smart" alarming whereby certain alarms can be automatically hidden from the operator based on the occurrence of specific process or plant conditions.

Determination of Plant State or Process Condition

The system shall provide a standard function block for determining / signaling changes in plant state or process condition from within the control strategy. This function block shall be capable of being combined with user-defined logic.

Configuration of Smart Alarming

The system shall provide tools and capability for easy configuration of which alarms will be "hidden" based on plant state or process condition. The configuration interface shall be a standard part of the Engineering system. It shall provide a spreadsheet style interface where alarms can be configured to be hidden / not hidden based on a simple checkbox.

Recording and Display of Hidden Alarms

Hidden alarms shall not be presented to the operator on the standard alarm displays or on process graphics, but their occurrence shall be recorded in the alarm history (journal). A "hidden alarm" display will be provided which lists all of the alarms that are currently hidden from the operator.

12.11 Alarm Shelving / Manual Alarm Hiding

To help plant personnel respond effectively to nuisance alarms or during plant upset conditions (alarm floods), the system shall provide the capability for the operator to manually hide individual alarms or groups of alarms on a temporary basis. A central configurable timer shall monitor how long the alarm has been "on the shelf" and will place it back in the operator's view when the time has elapsed. A comprehensive display listing "hidden alarms" shall provided to show alarms that have been hidden automatically based on smart alarm hiding techniques and manually based on operator shelving.

12.12 Alarm Management and Performance Monitoring

To monitor and optimize the performance of the operator in conjunction with the alarm system, the following capabilities shall be provided by the system as a standard.

Configuration of Troubleshooting information and Corrective Action

The system shall support the configuration of an information text message for each alarm state. This information text message can be used to display the probable cause of an alarm or the recommended corrective action. Information text messages shall be viewable from the standard alarm display list.

Recording of Alarm Comments

The system shall support operator entry of a comment upon acknowledgement of an alarm. The comment shall be stored in the alarm history where it shall be associated with the event. Comments shall be viewable at a later point in time from within the alarm history. To make it easy to locate alarms that have been commented, the alarm history display shall indicate which alarms have received comments and support quick identification by sorting and/or filtering.

Alarm Frequency Displays

To help plant personnel identify nuisance alarms, the system shall provide standard capability to perform and display an alarm frequency analysis which identifies those alarms that have occurred most frequently over a given period of time.

Alarm Message Duration / Time to Acknowledge Displays

To help plant personnel continuously improve operator response to alarms and to minimize the number of standing alarms, the system shall provide a display indicating the amount of time each alarm was active along with the amount of time that elapsed before it was acknowledged.

13 Industrial / Cyber Security

In order to protect the process automation system from the danger of hacker attacks, viruses etc., the vendor / system shall provide comprehensive industrial / cyber security capabilities consisting of products and procedures (best practices).

13.1 Use of "Defense in Depth" Architectures

The system shall support the use of a "Defense in Depth" strategy as recommended by the US Dept of Homeland Security. "Defense in Depth" advocates the creation of a nested security architecture by division of the plant into secure and closed security cells / segments with clearly defined and monitored access points.

13.2 Rules for Creation of Security Cells and Segments

The following rules shall be followed to ensure the creation of secure and fully functional security cells and segments:

- Each segment must form a self-sufficient "zone" that can be operated for a certain amount of time without connection to other segments; thus a segment must be capable of operating autonomously for a period of time.
- All components contained in a segment and involved in its function should be connected to one another (not through leased lines)
- Units that cause high network and computer load when connected from the outside via a complex security mechanism should be integrated directly in the segment
- Access to a security cell should take place only after the user's identity has been verified and logged and only under supervision of authorized persons, for example, physical access by operators.
- All connections to the Control System LAN should be routed through a firewall, with no connections circumventing it.

13.3 Securing network access points

The system shall allow clear demarcation between the protected internal network (control system LAN) and unprotected or untrusted external networks.

13.4 Use of Firewalls

The system shall support the use of firewalls to block selective (filter) traffic between network zones (subnets) or from a network to a device. To provide maximum

protection, firewalls must allow for rules to be created which allow only necessary access by employing one or more of the following techniques:

- Packet filtering
- Circuit level gateways
- Proxy gateways
- Stateful inspection

13.5 Supported Firewalls

The following firewalls shall be supported at a minimum:

- Windows XP Personal Firewall
- Microsoft SQL Server 2012 and latest.

13.6 Creation of Demilitarized Zones (DMZ)

The system shall support the ability to segment the network by use of demilitarized zones (DMZ). DMZs shall be used to provide a fault tolerant and secure access point for the following types of control system connections:

- Data Historian (when it communicates outside the control network)
- Web servers
- Security servers
- Networking Management Server,

14.0 User Management and Access Control

Central User Management

The system shall provide the capability of the central management of users within domains or workgroups providing the following specific capabilities:

- Create, delete, lock-out users
- Ensure IDs are unique

- Two-level ID (username + password) or Login Device (e.g. Card Reader)

Password Security

To ensure the security of the passwords used for accessing the system, the following capabilities shall be available:

- Specification of password properties (min. length ...)
- Limited time for password validity
- Expired passwords excluded for the next "n" generations
- Forced password change after first Log-On
- Auto – log-off after "n" minutes of inactivity
- Lock-out of users after "n" failed attempts to log-in.

Role-based Access Control (RBAC)

The system shall provide for user accounts with configurable access and permissions associated with the defined user role. The system shall support the implementation of the principle of minimal rights whereby users and computers can be configured with the minimum set of access rights necessary to perform their function.

Single Sign On

The system shall provide the ability for Single Sign On (SSO) authentication whereby a single login / password allows a user to have access to all programs (PC / Desktop Access, Engineering Tools, HMI, Batch Management) without requiring re-authentication for each application. The Single Sign on capability shall be capable of being used with Role-based Access Control (RBAC)

15.0 Software Security Patch Management & Testing

Continuous and immediate testing of new software security patches is critical to maintaining a secure network infrastructure.

Support for Immediate Installation of Microsoft Security Patches

If deemed necessary by the user, it shall be permissible to load the following new MS Security Patches on the system as soon as they are released from Microsoft:

- Windows operating system
- Internet Explorer
- SQL Server

Testing of Microsoft Security Patches

To ensure that the latest Microsoft Security patches have been tested for compatibility with the system, the vendor shall test new Microsoft security patches immediately upon their release. Results of the testing shall be communicated to end users so that they can choose when / if to update.

Software Update Service

The system shall support the use of the Windows Software Update Service (SUS) from Microsoft as a means to quickly and effectively implement automatic deployment of software updates and security patches on all PCs connected to the control network. The SUS Server shall allow viewing of all available updates so that they can be released as required in a procedure determined by the end user.

15.1 Use of Virus Scanners & Malware Detection

The system shall support the installation of Virus Scanners on all PCs attached to the control network. The following Virus Scanners shall be supported at minimum, with latest version.

- Trend Micro Office Scan
- Symantec Norton Antivirus
- McAfee Virusscan

Minimizing Impact on System Performance

To ensure that virus scanners do not have a negative impact on system performance, the vendor shall provide guidance on malware detection settings for use with their system based on the results of system compatibility testing.

Updates and Testing of New Signature Files

To ensure that virus scanners are able to be continuously updated to prevent new malware threats, the vendor shall test new virus signature files immediately upon their release. Results of the testing shall be communicated to end users so that they can choose when / if to update.

Installation and Operation of Virus Scanners

The Installation and Operation of Virus Scanners shall comply with the following:

- Engineering Stations and all other PCs where engineered data can be introduced to the Control System Network: Virus scanners shall be operated in a real-time mode with continuous scanning of all incoming traffic and shall support manual and periodic scans while offline (Runtime and Engineering)

- Operator Stations: Virus scanners shall be operated in real-time mode with continuous scanning of all incoming traffic (Runtime)

16.0 Auto Configuration of System Security Settings

To minimize the chance of error during the configuration of security settings, the system shall support the automatic configuration of Windows firewalls and registry entries.

16.1 Securing Access for Remote Maintenance / Troubleshooting

The system shall be capable of providing a secure connection for remote maintenance and troubleshooting. This access point shall be securable through use of local firewalls and virus scanning software at a minimum. The following methods shall be supported:

- Authentication and Encryption with IP Security (IPsec)
- Authentication and Encryption with Secure Sockets Layer (ssl and https)
- Use of VPN (Virtual Private Network) tunneling and Network Access Quarantine Control for Secure Support Access

16.2 Testing for Security Vulnerabilities

The system shall support the end user or designate testing for vulnerabilities using the Microsoft Baseline Security Analyzer (MBSA) or equivalent. Testing shall be able to identify the following conditions at a minimum:

- Open ports and protocols in use
- Missing Microsoft security patches

17.0 Diagnostics and Troubleshooting

On-line and off-line diagnostics shall be provided to assist in system maintenance and troubleshooting. Diagnostics shall be provided for every major system component and peripheral: including controllers, clients, servers, and communication devices. If diagnostics do not exist for particular peripheral devices such as printers and terminals, the system must detect and provide an error indication for the failure of these devices.

It shall be possible to monitor and troubleshoot PROFIBUS devices and HART devices from the control room without having to go out into the field. The system shall be capable of storing calibration information and device status history for each field device. It shall also be possible for the system to upload field device configuration changes implemented in the field. Once the configuration information

is stored in the system, it shall be possible to download it to any other similar device, whether a new or replacement device.
The system shall provide the capability of communication channel problem/error diagnosis.
The Operator Interface shall provide a heartbeat function to monitor the state of all the controllers and HMI components, and generate a message when a change is detected.
If a failure is detected in any backup equipment, the operator shall be notified and the failure shall be logged.

17.1 Events

All events generated by the system shall be captured and logged electronically in a to the event database, in chronological fashion, on a hard disk on one or more servers or single stations.

It shall be possible to retrieve and sort events by time (ascending or descending order) or by type.

All system events shall be time stamped at the point of origin. Events generated in the controller shall be time-stamped in the controller. Those generated in the workstation shall be time stamped in the workstation.

System events shall be defined to include the following at minimum:

- Intelligent Field Device Change in Status
  (e.g. Fault, Maintenance Required)
- Channel Failure (e.g. Wire Break)
- I/O Module Failure (e.g. Module External Failure detected)
- I/O Rack Failure
- Communication Module Failure
- Power Supply Failure (e.g. Battery Failure, Failure in 24V Source)
- Communication Network Failure (e.g. System Bus Failure)
- Controller Failure (e.g. Failover events)
- Server Failure (e.g. Loss of Redundancy)
- Condition & Performance Monitoring

17.2 Smart Event Suppression

The system shall provide smart event suppression whereby only the highest order error is reported to the Operator Interface. For example failure of an entire I/O Rack will result in the presentation of an I/O Rack error message, but not in an error message for each individual module located in the rack or from each individual channel of each module.

17.3 System and Diagnostic Displays

On-line displays shall indicate the results of self-diagnostic tests. Failure diagnosis shall be sufficiently specific to indicate which components, modules or devices are at fault. The displays shall be designed to help maintenance and engineering personnel diagnose faults in the system and communications paths. Each category of diagnostic display shall be organized logically to reflect its location in the system hardware architecture.

Within the Operator Interface, a display shall be available showing all controllers and HMI Components with their status.

17.4 Online Changes

The system shall support the ability to make the following changes online without interrupting operations:

- Changing the parameters of an I/O Channel
- Adding or Removing an I/O Module
- Adding or Removing a Rack of I/O
- Adding or Removing a PROFIBUS DP Slave
- Adding or Removing a PROFIBUS PA Field Device
- Adding new connections to Industrial Ethernet networks
- Modifying the range of an analog point
- Modifying a Process Graphic
- Adding a new tag to the Historian (Archive) database
- Adding a new Control Loop to the Configuration

18.0 Maintenance and Asset-Management

18.1 Core Functions

The maintenance system shall provide the following core functions:

- Monitoring of the control system components
- Monitoring of technological components (e.g. heat exchangers, valves)
- Monitoring of plant components
- Acquisition of the asset identities

- Condition monitoring
- Acquisition of detail diagnostics
- Interface to specialist tools
- Generation of maintenance requests (including predictive ones)
- Provision of maintenance data for all assets in uniform structure and form for subsequent processing stages
- Commissioning support
- Logging of events and maintenance measures
- Controller load analysis: load, tasks, alarm capabilities when configurable load limits are violated.
- Status of the terminal and system bus redundancy
- Status of inputs/outputs redundancy, channel-based
- Hit list for asset alarms
- Comprehensive asset comments are displayed on the OS
- Up to 10 documents can be assigned to one field instrument
- Performance and load analysis must be possible without additional hardware costs
- The system shall support diagnostics and parameter assignment channel-by-channel.
- Diagnostic information on network (bus load, bursts, data frame loss etc.)

18.2 Required Properties

The maintenance system shall fulfill the following properties:

- Industry sector neutral package
- Integrated in the process control system
- Link to engineering data with no additional configuration or engineering needed.
- Uniform and plant-wide representation of the diagnostics and maintenance state (using uniform symbols or icons).
- Integration of field devices from all manufacturers.
- Separate evaluation of maintenance and process-relevant information.
- Visualization of all plant sections in uniform fashion.
- OS (HMI) "look and feel" in conformity with that of the process system.

- Workflow optimization from diagnostics to completion of the maintenance. It must be possible to minimize production losses and down-time.
- Comprehensive support of condition/state-based maintenance.

18.3 NAMUR

The system should be based on the following NAMUR recommendations:

- NAMUR NE 91 Requirements for plant oriented Asset Management
- NAMUR NE 105 Requirements for Integration of fieldbus connected instruments in Engineering Tools for Field Devices
- NAMUR NE 107 or VDI/VDE/NAMUR/WIB 2650 Self-test and Diagnostics of Field Devices

The vendor system shall provide component-spanning and automatic system diagnostics & help functions as well as role-based asset processing (read, write, maintenance personnel, specialists).

The system shall provide tools and capabilities which enable preventative and predictive maintenance techniques to be employed for all of the critical assets in a plant including but not limited to motors, pumps, analyzers, transmitters and valve positioners.

18.4 Computerized Maintenance Management Station (CMMS)

The system shall support the creation of a dedicated and integrated maintenance station which can provide comprehensive maintenance information for all plant assets such as Pumps, rotating equipments, valves, instruments, control equipments, Chemical equipments, etc..

It shall provide the same HMI interface (look and feel) as a standard operator HMI display that would be used for viewing the process.

The basic diagnostic data for all assets will be displayed on a uniform set of faceplates. Detailed diagnostic displays can also be called up representing the following:

- An online view of the hardware configuration
- Online view of a smart field device through the field device management tool

18.5 Integrated Plant Asset Management System

Integrated plant asset management capabilities should be provided by the system for all of the following assets such as Pumps, rotating equipments, valves, instruments, control equipments, Chemical equipments, etc..

- Transmitters & Valve Positioners
- Motors, Pumps and Drives
- Analyzers
- PC's (Servers, Clients, Historians, etc.)
- DCS Hardware (controllers, I/O modules, etc.)
- Networking Equipment (switches, etc.)
- Plant equipment assets (User definable)

18.6 Auto Generation of Asset Management Database & Visualization

The system shall automatically populate the asset management database directly from the application program and hardware configuration. No additional entry of basic information for the asset management configuration shall be required.

Faceplates and symbols will be automatically created within the HMI to allow plant personnel to easily visualize and monitor the asset's operating performance. Special summary displays are provided for viewing of asset alarms.

18.7 Integration of Smart Motor Control Centers (MCC)

The system shall support the direct integration of VFD, Smart Motor Control centers via PROFIBUS. This will allow information on the motor's operating condition to be sent directly to the system via a digital field bus. Optional pre-engineered libraries of function blocks and faceplates shall be available to support easy integration of Smart MCCs into the controller and HMI applications. The necessary cabling and duct to be provided between VFD to the DCS controller and provide the future provision to interface with VFD.

18.8 Condition and Performance Monitoring

It is often necessary to consider certain process, chemical and mechanical conditions in the context of a maintenance concept for a plant. As such the system shall support Condition Monitoring whereby the user can be automatically notified before the operating conditions of critical equipment (such as pumps and bearings) goes beyond acceptable levels.

Standard Function Block for Monitoring of User Defined Assets and Conditions

The system shall provide a standard set of function blocks and faceplates that can be used to monitor the condition and performance of user-defined plant equipment assets. The system shall allow user-defined logic to be combined with the values already measured by the system, in order to monitor the performance of critical assets such as heat exchangers (fouling) and pumps (power consumption, deviations from characteristic curves etc)

The status of user-defined assets shall be displayed within the maintenance station along with those created automatically by the asset management system. Information and status displays will be displayed using a common set of faceplates and summary display lists.

18.9 Document Management

The system shall include document management capability allowing the storage and display of up to 10 different files (DOC, PDF, MPG, AVI etc.) for each device. This allows information such as standard operating procedures, wiring diagrams, P&IDs or help files, to be called up from the central maintenance station.

19.0 Handling of Material Transports

The quoted DCS shall provide an additional tool for the configuration, control, monitoring and diagnostics of material transports in pipeline networks which is not specialized on any particular industry.

19.1 General

The vendor's route control shall provide the following functionalities:

- Operation of range of transport routes from simple to complex
- Automatic route searches for transporting materials in plants and storage depots.
- Configuration, control and monitoring and error diagnostics of material transport in pipeline networks.
- Use in plants with numerous complex route combinations or large storage depots
- Operation of plants with numerous pipelines with high flexibility

19.2 Configuration

The route control configuration shall be based on the basic configuration of the process control system with blocks from the vendor's standard library. It must be possible to simply expand existing plants with the route control.

The system shall offer configuration components:

- Library with uniform interface blocks for configuration
- Wizard as an interface between the route control configuration and process control system basic configuration
- Engineering tool for simple configuration of routes, partial routes and properties.

19.3 Architecture

Route control shall be able to use the basic hardware of the process control system.

In small plants, it shall be possible to combine the operator system and route control on a single station.

The route control shall allow client-server configurations, expandable with up to 32 route control clients per server.

It shall be possible to install the control center of the route control on an OS Client or Batch client, but also to configure it as a separate route control client.

The route control engineering must be integrated in the engineering toolset of the vendor's central engineering system.

19.4 Route Control in Runtime

The following runtime components shall be available for operating, visualizing and diagnosing material transports:

- Route control block icons (status of a route, e.g. manual mode, fault etc.)
- Route controls faceplate (operation and visualization for a route)
- Route control center (operation and visualization for all routes)

19.5 Maintenance in the Route Control

Service personnel shall have the option of setting the automation system to the "Maintenance" state for the route control system. New material transports are then blocked.

19.6 Fault-tolerance

The route control system shall support fault-tolerant (fail-safe) automation systems. Suitable route control library functions must be provided.

19.7 Operating System

The route control system shall run on the Windows XP Professional or Windows Vista Server operating systems or latest editions..

19.8 Engineering Station

The system shall support configuration of the route control servers via the central engineering station. Wizards must be provided for generating the designated communication connections.

19.9 Material Change

The system shall provide the option for manually changing material in an active material transport. It must be possible to set special material properties.

19.10 System Safety Route Control

For system security reasons the system shall allow reading/writing of distributed Windows folders only for specific route control user groups. The "everyone" attribute is not allowed.

20.0 Process Simulation

The system shall support various levels of tools for simulation of processes.

The simulation system shall be able to run on a PC-based system with Windows XP or Windows vista.

The system shall allow commissioning in a virtual plant.

The system shall support training for plant personnel.

It shall be possible to import existing architecture information into the system to avoid duplicate data input and the associated error source.
A fully graphic user interface should simplify operation. The available know-how of a process engineer or automation engineer should be sufficient for fast, comprehensive training. Special knowledge about simulation should not be necessary.

20.1 Controller Simulation

A controller simulation tool shall be available which shall allow simulation of field inputs and outputs within the control logic and to facilitate testing and troubleshooting of the controller program. It shall require no control or I/O hardware and shall be capable of being used to simulate Continuous processes. It shall not require special modifications of the actual controller program to be able to be run in simulation mode.

20.2 Simulation of Remote I/O and PROFIBUS Devices

The system shall support the use of cards which are capable of simulating the actual electrical signals and responses of remote I/O and PROFIBUS field devices to an actual controller.

It must be possible to import the field devices to be simulated, from the hardware configuration of the plant.

The simulation of the PROFIBUS-DP nodes must be performed without reaction by the controller, i.e. the controller shall not distinguish between real and simulated field devices communicating on the bus.

The system shall allow error simulation on the PROFIBUS. This includes:

- Stations failure
- Module failure
- Channel and cable diagnostics

The system must offer simulation of aggregates using prefabricated libraries and editable software functions (sequencers, interlocks, DP redundancy).

The simulation must allow testing of virtual field devices (on the Profibus DP / PA) without mechanical stress or danger to the real installation.

20.3 Process Modeling

The system shall support the use of higher order Process Simulation programs that are capable of modeling the process dynamics. These programs shall be capable of making use of the actual control program or database extracted from the control program for the development of the model (maximizing reuse), including export / import of the hardware configuration data.

The controller simulation shall be able to communicate with various communication interfaces (OPC etc.). The vendor shall provide prefabricated, freely-programmable libraries for this.

The simulation shall allow modeling of process engineering factors with scalable detail precision and support the following functions:

- Drag-and-Drop modeling through a graphic interface
- Integrated mathematics
- Component libraries with definable properties
- Equation-based modeling
- Macro components
- Model sectors
- Dynamic graphics and animations

The system shall allow running realtime simulation. Realtime synchronization must be possible.

It must be possible to save and reuse modeled scenarios. The reuse should be facilitated by integrated management.

The simulation system shall support the connection of process visualization. It must be possible to visualize and animate the simulation.

The system shall support simulation analysis with logs, trends and messages.

It must be possible to test software changes independent of the real plant.

The simulation must run on the process level, device level and signal level.

21.0 Historical Data Handling

The Operator Interface shall provide a complete historical (archiving) subsystem providing the user the capability to capture and analyze historical data.

A high-performance central archive server shall be provided for handling (long-term) archives. The system shall allow selection of any point in the system to be added and configured for archiving.

The archiving system shall utilize a Microsoft SQL real-time relational database for storage of all process related data. Flat file or internal proprietary databases will not be accepted.

The archiving system shall be configured using standard tools provided by the system to facilitate the display and editing of archive rates, archive types, etc. from graphical and tabular data displays.

The system shall support the online addition of new tags to the historical database with out interrupting operations.

The historical subsystem shall promote the visualization of historical data in both tabular and graphical form. This includes the capability to view historical data via a web-enabled interface.

21.1 Archiving Capability

The historical subsystem shall provide the ability to define archiving rates in increments of milliseconds, seconds, minutes, hours, or days.

The historical system shall allow an individual archive rate to be programmatically modified and/or utilized as part of the Control Logic/Scripting requirements specified above.

The historical subsystem shall include the capability to archive values per analog point including but not limited to:

- actual value
- maximum
- minimum
- sum
- mean

The historical subsystem shall include the capability to archive digital values on either a rising or falling edge.

21.2 Database Capacity

The system shall support archiving of up to 10,000 different variables per OS Server.

A central archive server shall support the archiving of up to 30,000 different variables.

At a minimum the historical subsystem shall have the capability to continuously archive at least 1000 samples of up to forty (40) data values at rate of 500 ms.

A data compression algorithm shall be available to minimize the storage space required by the archives.

21.3 Backing Up the Database

The system shall supply tools for automatically backing up the database to removable media or to an alternate storage location. The backup utility shall execute the database backups automatically based on either of the following configurable criteria:

- Time-based (e.g. every 24 hours)
- Based on the size of the database.

21.4 Redundancy

The system shall support the use of redundant historical archives and storage of archive databases on separate PCs.

Redundant historical archives will be automatically synchronized when the partner is returned to service.

21.5 Trend Displays

Every operator workstation shall provide viewing for real-time and historical trend information. Data collected in any historian package shall be available to all workstations. The system must support a centralized approach to historical data collection.

The system shall support user defined sets of trends so that commonly viewed historical information can be defined in trends once and easily accessed by selecting a pre-configured screen target incorporated in the graphic display. There should be no practical limit to the number of trends that can be defined. Each trend screen shall support up to 8 separate pens. Selection of points to be trended shall be menu driven.

Historical trends shall support seamless integration of both real-time and historical data within a single trend window, with seamless movement between the two. In the

event that the screen is scrolled to the left, then historical values will be recalled from historical data files. Scrolling the trend far enough to the right will result in current real-time data being displayed as it is collected.

Zoom in/out and moving forwards and backwards in time shall be possible with no more than two operator actions. A mechanism for selecting a location on the trend, such as a hairline cursor and reading the numeric values of the trends at that point in time shall be provided.

It shall be possible to call up new historic trends and configure them online from the Operator Interface.

Pre-configured real-time trends shall be available from a faceplate.

It shall be possible to export data associated with a currently displayed trend to a .csv file for viewing in MS Excel.

22.0 Reporting

The Operator Interface shall provide an integral reporting subsystem used to report both current and archived data.
The reporting subsystem shall utilize standard Windows tree / list view presentation techniques for management and administration of reports.

The reporting subsystem shall provide the capability to define reports for both visualization and printed format. Report templates shall be supplied which can be modified or used as is.

The reporting subsystem shall allow individual reports to be programmatically modified and/or utilized as part of the Control Logic/Scripting requirements.

The reporting subsystem shall provide the capability to define both the dynamic and static properties reports, including but not limited to:

- Inclusion of archived data, alarm data or event data,
- Customization of the format, layout, and graphical images, included on a report.
- Configuration of automatic report generation, including frequency, destination of the report, and a prioritized list of alternate system resources should problems be encountered during automatic production.

The reporting subsystem shall not impose limits on the number of reports that can be configured.
The system shall support the use of optional third party applications (i.e. Excel, Crystal Reports) for generation of reports.

Report Generation

It shall be possible for all reports to be displayed on a workstation screen as well as printed on a report printer. Hourly, daily, monthly, end-of-month, quarterly and yearly reports shall be supported.

Reports shall be printed and/or saved to disk when a process event occurs. It shall be possible to activate a report in any of the following manners:

- Upon demand (operator request)
- Scheduled (shift, daily and monthly)
- Upon event occurrence

Preconfigured Report Templates

The reporting subsystem shall be supplied with pre-configured reports including but not limited to:

- Graphic display documentation
- Historical archiving
- Alarm archiving

23.0 Reliability

A single failure anywhere in the system shall not result in the loss of regulatory control to more control loops than those associated with a single process input/output card. Failure of any single device shall not affect the ability of the system to communicate with other devices in the system. Switchover shall not disrupt any system functions.

23.1Redundancy

Redundancy shall be available over all levels of the automation system, including controllers, power supplies, networks, I/O racks, Clients, and HMI servers, and Historians.

Redundant equipment and software shall be continuously monitored for errors. All modules shall be diagnosed on-line. Errors shall be alarmed with an error message identifying the failed module.

To maximize data availability and integrity, the Operator Interface shall provide the ability for configuration of system redundancy. This shall in no way limit or restrict the use of the client/server configuration and/or architecture.

Clients shall automatically failover to the backup or redundant server. This operation shall not require any application reprogramming or reconfiguration.

System redundancy shall be configurable on a server by server basis up to a profile of twelve redundant servers.

Client stations shall support the designation of different primary servers allowing the network loading to be distributed and to ensure that in the event of a failure not all clients will experience a switchover.

- Each component can be configured redundantly (2-3 fold redundancy).
- Redundant field bus architecture allows multiple errors without causing interruption. A ring-shaped field bus should be used to increase availability.

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24.0 Safety

The vendor of the process control system shall offer integrated control and safety functions that provide the following advantages:

Control and Safety functions are integrated in the vendor system, meaning less hardware is required, less personnel training is necessary and the system is easier to operate.

Highest availability due to architecture with multiple fault tolerance

Highest flexibility since safety and standard application is possible in a single CPU and Profibus safe can be used simultaneously on PROFIBUS.

Integrated safety field bus.

Less wiring, prepared for safe process instrumentation.

Safe life cycle engineering with safety matrix.

No additional communication busses needed for fail-safe technology.

No additional controller needed for fail-safe technology.

The system shall support safety programming with CFC and other fail-safe tools.

24.1 Configuration of Fail Safe Systems

The configuration of fail-safe systems shall automatically supplement user-specific CFCs with functions required for error detection and reaction. The configuration of fail-safe systems shall be performed with the same tools used for the non-fail-safe application.

Support for Safety Communication

The system shall support the use of profibus for communication to and from smart instruments even in a redundant / fault tolerant architecture. The profibus protocol ensures that reliable and fail-safe communication takes place between smart field devices and their controller over PROFIBUS Dp.

24.2 Fail-safe Controllers

Manufacture shall provide failsafe and fault to controllers

24.3 Use of Shared Hardware

To minimize spare parts requirements the system shall support shared use of hardware (CPU, power supply, backplane bus and communication modules) for both safety-related and non-safety-related applications.

25.0 Remote Access and Links to other Systems

25.1 Support for third party connectivity

The system shall be capable of communicating with third party control systems by using of the following interfaces and protocols:

- OPC
- PROFIBUS
- Foundation Fieldbus (FF)
- Ethernet
- Serial Interface (e.g. Modbus),

25.2 Serial Interface

The following capabilities shall be available for communicating to auxiliary systems:

- RS-232C, RS-422, and RS-485 with full and half-duplex operation, and selectable baud rates (19200, 38400, 57600, and 115200)
- IEEE 802.3 Ethernet protocol at 100 or 1000 MBPS, with TCP/IP
- Modbus configured in a master-slave relationship, with the system as the master and the auxiliary system as the slave.

25.3 OPC Interface

The system shall be able to communicate bi-directionally with auxiliary systems using OPC. The OPC interface shall be configured in a client-server relationship and as such the system shall be able to act as either the OPC Client or OPC Server as required.

The vendor system shall provide access to alarms and events via OPC standard interfaces. There shall be no need to write any custom code to set up the OPC interface. Configuring the OPC shall be done using drag-and-drop functionality to link the data source and target.

At a minimum, the OPC interface shall support scan rates of 500 ms and 1 milli-second.

The Interface should be capable of handling a Data throughput rate of 15,000 tags / sec.

25.4 Integration with Enterprise Systems

The system shall be capable of interfacing with ERP systems (such as SAP) through the use of optional Information Technology (IT) software modules developed based

on the ISA S95 standards. The following optional IT modules shall be available at a minimum:

- Production Scheduling
- Asset / Maintenance Management
- Material Management
- Historical Records / KPI Management
- Compliance Management

IT Modules shall support a plug-in architecture whereby a Framework is provided for interfacing between the process automation system and the ERP/MES system

25.5 Remote Access

It shall be possible to remotely access the system by modem (DSL or ISDN) for troubleshooting purposes.

The user shall have the capability to disable this feature without disconnecting the modem.

25.6 Weighing Systems

The system shall offer integral weighing technology with engineering involving little work.

25.7 Video Integration

The system shall provide video integration as a separate network..

25.8 High-Performance Controller (closed-loop) Hardware

The system must support the optional integration of high-performance closed-loop controller hardware.

25.9 Distributed Hardware

The system shall provide intrinsically safe interfaces / couplers for the distributed I/O, field devices.

They should be designed modular and flexible and satisfy rugged design norms.

It should be easy to perform the installation using rails and integrated connectors.

It should be possible to connect the sensors and actuators via the bus system.

"Permanent wiring" shall be possible, to make it easier to exchange modules without removing the wiring.

It should be possible to perform replacement during ongoing operation (hot swapping)

It should be possible to also use the I/O Interfaces and couplers in hazardous areas. (Ex areas)

All devices are certified according to guideline 94/9/EC.

The system shall be compatible for universal I/O cards, to avoid high storage costs.

25.10 Configuration and Diagnostics

The configuration and diagnostic capability shall be available locally or centrally via the configuration of the vendor system.

Full online expandability shall be possible.

26.0 Documentation

Documentation covering the system hardware, software, and configuration tools shall be available.

The system vendor shall provide a complete set of CDROM/DVD based manuals.

The system shall offer comprehensive context sensitive help.

Whenever possible, the vendor shall supply custom documentation by using standard functionality embedded in the system. All documentation shall be provided in English, German and French.

A plant documentation utility shall be available, which generates plant documentation in accordance with standards.

27.0 Support Services

The vendor shall offer phone and email support, Internet information, and training courses.

The vendor shall offer global 24/7 support for all system hardware and software. This shall include spare parts, maintenance, and technical support.

Telephone support related to current product issues shall be free of charge during business hours

The vendor shall offer comprehensive self directed technical support via the Internet that shall include but not be limited to:

- Contact with technical support via email
- Searchable knowledge base
- Product catalogs and manuals
- Product Frequently Asked Questions (FAQs)
- Software updates
- Application examples
- Application Tips

As an option the vendor shall offer a comprehensive software maintenance plan that shall include but not be limited to providing:

- Latest product version(s)

- Updated knowledge base
- Updated electronic manuals

28.0Training Programs

The vendor shall offer complete and comprehensive training programs for the system, including the controller, networks, and OS.

- Controller hardware training course content shall include, but not be limited to:
  - CPU, power supply, communication cards, backplane, local and remote I/O racks.
  - I/O cards
  - Profibus and Ethernet communication
  - Fault tolerant architecture and fail-safe architecture.

- OS hardware training course content shall include, but not be limited to:
  - OS System Overview
  - OS client and server architecture, including networking and redundancy
  - The display hierarchy, and the graphical, trending, alarm, reporting, and batch displays

- Controller engineering training course content shall include, but not be limited to tools for:
  - Configuration of the I/O hardware devices
  - Configuration of the communication networks
  - Configuration of continuous and sequential control operations
  - Design of operating and monitoring strategies

- OS engineering training course content shall include, but not be limited to tools for:
  - Introduction to Windows
  - Creation of an OS system application
  - Creation, administration and management of OS system database
  - Creation, administration, and management of graphics displays
  - Creation, administration, and management of system alarming

- Creation, administration, and management of the historical subsystem
- Creation, administration, and management of the reporting subsystem
- HMI Scripting

The vendor shall offer regularly scheduled classes at training centers in all areas/regions of the country. The vendor shall publish course schedules and allow customer registration via the Internet.

29.0 Definitions

This section contains definitions for acronyms, abbreviations, words, and terms as they are used in this document.

30.0 Acronyms and Abbreviations

AGLP	Add Domain User Account to Global Group, Add Global Group to Local Group and Assign Permission
ALP	Add User Account to Local Group and Assign Permission
CPU	Central Processing Unit
EIA	Electronic Industries Association
EMI	Electromagnetic Interference
HART	Highway Addressable Remote Transducer
HMI	Human Machine Interface
IEC	International Electrotechnical Commission
DCS	Distributed Control system.
PCU	Process Control Unit.
I/O	Input/Output
ISA	The Instrumentation, Systems, and Automation Society
MTBF	Mean Time Between Failures
OLE	Object Linking and Embedding
OPC	OLE for Process Control
OS	Operator Station
PC	Personal Computer
PO	Process Object
RFI	Radio Frequency Interference
RTX	Real time extension for Windows

31.0 Words and Terms

Alarm Logging: Editor for configuring the message system in the operator station and the application for displaying, archiving, and handling messages.

Archive: Saving measured values and messages in the operator station to history so the data can be called up over a long period of time.

AS-Interface: The Actuator Sensor Interface is a networking system for field mounted binary sensors and actuators.

Audible signal device: Horn, bell, buzzer, or similar device indicating that a new alarm or message has arrived at the operator station.

Availability: The probability that a system will be able to perform its designated function when required.

Blocks: Blocks are separate parts of a user control software configuration distinguished by their function, structure, and purpose.

Bus: A path for electrical signals allowing the exchange of data between various components of a computer or system.

Central Processing Unit (CPU): The central part of the controller in which the user program is stored and processed, and the operating system and communication interfaces are contained.

CFC: Continuous Function Chart is a high-level graphical language using function blocks for configuring continuous control systems.

Chart: The document in which the automation functions can be created using the CFC tool or the SFC tool.

Communications Link: The hardware and software that performs the transmitting and receiving of digital information over a communication system, for example a bus.

Configurable: The capability to select and connect standard hardware modules (blocks) to create a system; or the capability to change functionality or sizing of software functions by changing parameters without having to modify or regenerate software.

Configuration: The physical installation of hardware modules to satisfy system requirements; or the selection of software options to satisfy system requirements.

CSV: Comma Separated Values, an ASCII text format in which tabular data are saved.

Cycle: In the controller, the scanning of inputs, execution of algorithms by the controller, and transmission of output values to devices.

Discrete Control: Control where inputs, algorithms, and outputs are based on logical (True or False) values.

Distributed I/O: Field devices or analog and digital modules located at a distance from their central controller.

Engineering Workstation (ES): Computer equipment that includes a PC, a monitor, a keyboard and an appropriate pointing device, used by technically-trained personnel to configure the control system.

Ethernet: Hardware type standard for data transmission using coax, twisted pair, fiber optic cable, or wireless, usually running at 1000 Mbps (see Fast Ethernet).

Faceplate: On the Operator Station screen, a graphic element that represents, for example, an analog controller instrument, a hardwired push-button, or a switch, allowing operator monitoring and control of the device.

Fast Ethernet: A faster version of Ethernet running at 100 Mbps.

Gigabit Ethernet: Ethernet with transmission rates of 1000 Mbps

Fault-tolerant system: A system in which all essential components (such as CPU, Power supplies, racks etc) are duplicated, allowing the backup device to take over from the primary device without control interruption if a failure occurs.

Foundation Fieldbus: The ISA/IEC Foundation Fieldbus standard covers a communication system for field mounted measurement and control devices.

Function Block: A control bock as defined in IEC 1131-3. See also Block.

GPS: Global Positioning System, a satellite based system, which provides the exact position anywhere on earth, and the time of day.

Human Machine Interface (HMI): The graphical interface program for allowing an operator to interact with and control a process.

Instance: A copy of a function block, which is used again in the control configuration for a similar application.

Invalid Value: The state of a tag value, which indicates that the quantity being measured or calculated, is out-of-range, not measurable, or not calculable.

Ladder logic (LAD): Graphical representation of the automation task using relay symbols complying with DIN 19239.

Lifebeat Monitoring: An operator station program, which monitors the controllers, servers, and operator stations, and provides a plant picture with the status.

Logs: Files or printouts of information in chronological order.

Mode: Control block operational condition, such as manual, automatic, or cascade.

Module: An assembly of interconnected components that constitute an identifiable device, instrument, or piece of equipment. A module can be disconnected, removed as a unit, and replaced with a spare. It has definable performance characteristics that permit it to be tested as a unit.

OPC: Object Linking and Embedding for Process Control, a software application, which allows bi-directional data flow between two separate applications.

Operator Station (OS): Electronic equipment on which the HMI resides, including, at a minimum, PC workstation, a monitor, keyboard, and pointing device used by an operator to monitor and control his assigned process or manufacturing units.

PLC: Programmable Logic Controller, used for discrete and continuous control in processing and manufacturing plants.

PROFIBUS: Process Field Bus, a field bus complying with EN 50170 Vol. 2 PROFIBUS (DIN 19245; bus system for industrial application based on PROFIBUS).

Plug and Play: The ability of hardware equipment to automatically identify itself to the system. When the equipment is powered up it is automatically assigned a unique identity without the need to set any dipswitches.

Point: A process variable derived from an input signal or calculated in a process calculation.

Process Object: A collection of variables and parameters that performs a control function (e.g. motor, block valve, PID Controller) which may consist of more than one I/O point.

Redundant: A system/subsystem with two modules that provides automatic switchover to a backup in the event of a failure, without loss of a system function.

Regulatory Control: The functions of process measurement, control algorithm execution, and final control device actuator that provide closed loop control of a plant process.

Reliability: The probability that the system or component will perform its intended function for a specified period of time, usually measured as Mean Time Between Failures.

Structured Control Language (SCL): A high-level language complying with IEC 1131-3 and resembling Pascal for programming complex or custom logic tasks within the controller.

Self-Diagnostic: The capability of an electronic device to monitor its own status and indicate faults that occur within itself.

Security: System access control by key lock, password, electronic card, or other equivalent method.

Sequential Control: A type of discrete control handling sequential processes.

Sequential Function Chart (SFC): Sequential Function Charts are a high-level graphical configuration language for sequential control applications.

Statement List (STL): Statement List is a textual programming language resembling machine code and complying with IEC 1131-3.

System Bus: The network used for communication between controllers and HMI servers.

Tag: A collection of attributes that specify either a control loop or a process variable, or a measured input, or a calculated value, or some combination of these, and all associated control and output algorithms. Each tag is unique.

Tag Id: The unique alphanumeric code assigned to inputs, outputs, equipment items, and control blocks. The tag ID might include the plant area identifier.

Terminal Bus: The network used for communication between HMI Clients and HMI servers.

Time synchronization: Time Synch is provided by the operator station to make sure that all PCUs and operator stations on the bus operate with the same time of day.

Government of State of Kuwait
Ministry of Electricity and Water

Section 4C.2

Technical Specification for

General Instrumentation and Control

Contents Summary

Section 4F.2

General Instrumentation and Control

Part 1 General

1.01 Description

A This Section covers the general requirements for furnishing and installation of all instrumentation, control and monitoring (ICM) systems complete in every detail for the purposes specified and shall form a part of all ICM Section of particular spec of unless otherwise specified. Other ICM Sections shall supplement this Section as necessary.

B Work Included in the ICM Section Particular spec. The intent of the ICM Sections of Sec. 4C.01 to 4C.28 is to require that the complete Instrumentation, Control and Monitoring System, i.e., primary elements, panel mounted and miscellaneous field instruments, etc. shall be furnished by the DCS Manufacturer to assure system uniformity, subsystem compatibility and coordination of all system interfaces.

The Contractor shall subcontract the work under these Telemetry, Instrumentation and Control sections to a qualified DCS manufacturer as a sub-contractor who shall perform said work. The Main Contractor should understood that this shall not relieve him from any responsibility under this Contract.

The review/approval of any documents or drawings from MEW shall not relieve the contractor's responsibility to meet the requirements as specified in tender specification, drawings or BOQ, even after commissioning the work, expect the Deviations approved by the MEW.

The **Deviations may be considered in special circumstances, but must be clearly mentioned in a separate official letter 'Deviation Note with Proper Justification'' and shall be subject to MEW Engineer approval.**

C Furnish all tools, equipment, materials, and supplies and perform all labor required to complete the furnishing and installation of, including all instrumentation signal and power conduit and wiring not specifically shown on the electrical drawings, validation, start-up and operational testing of a complete and operable Instrumentation, Control and Monitoring System as indicated on the Drawings and as specified herein.

D Provide all the necessary equipment components and interconnections and the services of the manufacturers, engineering representatives for the engineering, implementation, startup, operation, and instruction, to insure that the Employer receives a completely integrated and operational ICM system as herein specified.

1.02 System Responsibility

A The Contractor's attention is directed to the fact that the ICM system as specified in these ICM Sec.4C.01 spec. as a integrated system and therefore shall be provided by a single competent, qualified **DCS system manufacturer** as a Subcontractor (hereinafter referred to in these ICM Sections as the ICM Subcontractor) who shall have total responsibility for the

ICM work of this Division. The entire system installation including calibration, validation, start-up, operational testing, and training shall be performed by qualified personnel, possessing all the necessary equipment and related to this project. The System shall be integrated using the manufacturer's latest most modern product and proven design and shall, as far as practical, be of one manufacturer. Overall system performance shall be guaranteed by the DCS manufacturer.

C The DCS Manufacturer shall be responsible for the correct installation of all hardware and systems specified in these ICM Sections. Certain Primary Elements, Final Control Elements, etc., although provided as part of this Division, shall be installed in the process lines under other Divisions of these Specifications; however, this installation shall be under the direct supervision of the DCS manufacturer.

D The DCS system manufacturer shall be responsible to see that all components of the instrumentation system, including primary measuring, indicating, transmitting, receiving, recording, totalizing, controlling, and alarming devices and all appurtenances, are completely compatible and shall function as outlined and he shall furnish and install such additional equipment, accessories, etc. as are necessary to meet these objectives at no cost to Employer.

1.03 Quality Assurance

A. The DCS Manufacturer shall be a recognized DCS systems manufacturer, a panel fabricator, and installer of field instruments. The DCS Manufacturer shall have a minimum of 10 years documented experience in providing ICM equipment on a single system responsibility basis for municipal water and wastewater treatment processes, one of the approved vendor list. Also, the personnel employed for system engineering, supervision, start-up, operational testing and training shall be regular employees. The DCS Manufacturer shall be fully responsible for the technical supervision of the installation to ensure that it is proper in all respects.

B. At the time of quoting to prospective Contractors prior to tender opening, each prospective single DCS Manufacturer shall execute and submit a written certification of intent to assume full responsibility for the complete requirements of all ICM Sections.

C Each prospective Contractor shall include with his tender a certification completed by the proposed single DCS system manufacturer for ICA contractor. The certification shall be signed by his authorized responsible representative, and it shall include the following statement.

Corporate name of Telemetry, Instrumentation and Control Works as a Subcontractor
(From one of the DCS manufacturer from the pre-qualified list and original origin)

hereby certifies intent to assume and execute full responsibility to select, to furnish, to supervise installation and connection, to test, calibrate, validate, and place into operation, all meters, instruments, alarm equipment, control panels, and all other assemblies, components, and accessories needed to place into service complete operating process control systems, and in full compliance with the requirements of all ICM Sections.

In addition, it is certified that drawings and data will be prepared and submitted, specified field services will be performed by qualified personnel, operating personnel will be instructed, and technical manuals will be prepared and submitted, all as required by the ICM Sections.

Finally, it is certified that the quotation offered provides for full and complete compliance with the requirements of the ICM Sections of Divisions without exception.

D Standard of Quality, Furnish equipment of the types and sizes specified which has been demonstrated to operate successfully. Wherever on the Drawings and in these Specifications, materials or equipment have been specified by using the name of products or manufacturers, the term "or equal and approved" is always understood to follow immediately. Material or equipment, so specified, have been selected as being most suitable and are regarded as a standard and are not intended to eliminate others of equal quality and performance. Workmanship for the installation of instruments, wiring, piping, painting and labeling shall be equal to the best industrial standards for instrumentation and control work. All instrument equipment and materials, including their installation, shall conform to specification and international std.

E Factory Inspection, The Engineer or his representative may inspect fabricated equipment at the factory. Notify the Engineer in sufficient time so that factory inspection can be arranged. Factory inspection shall be made only after manufacturer has performed satisfactory checks, adjustments, tests and operations. Tests shall be made using simulated inputs and output loads. Approval of equipment at the factory only allows the manufacturer to ship the equipment to the site, and does not constitute final acceptance by the Engineer.

F The Engineer will indicate on return of the approved submittal each item requiring factory inspection. Lack of such indication by the Engineer shall constitute a waiver of factory inspection.

1.04 Submittals

A. Refer to this Section for required method of preparation and transmittal, and conform to requirements herein.

B. The DCS Manufacturer shall provide all drawings, data and information required to supplement the Drawings. The following information relative to the work of the ICM sections shall be the responsibility of the DCS Manufacturer to determine, furnish, coordinate with other Divisions, and submit for approval, based upon the systems specified.

The contractor should submit the following documents as a min. requirements of the project, within four weeks from the date of signing the contract.

Drawings/Documents:-

1 Overall System Network Layout
2 P&I'D Diagrams.
3 Cause & Effect chart.
4 Instrument Index.
5 I/O List.
6 Instrument Data sheets.
7 Instrument Schedule (alarms & setpoints)
8 Cable Block Diagrams.
9 Cable Schedule.
10 Instrument Loop Diagrams.
11 Instrument Location and Cable Route layout Diagrams.
12 Instrument Hook up Diagrams.
13 Panel Inter-connection Wiring Diagrams.

14 Panel location & Installation diagrams
15 Electric power wiring circuits and schematics
15 Electric signal wiring circuits and schematics
16 Pneumatic signal tubing schematics
17 Fabrication/Shop drawings
18 General Arrangement of panels and internal accessories
listing of all panel mounted (both front and rear) instruments
19 Control panel layouts and nameplate inscriptions

Documents:-
20 Functional Design Specification.
21 Functional flow chart.
22 Ladder logics.
23 DCS I/O mapping and Address.
24 Software Design Specification.
(HMI graphics, Alarms, events, SOE, reports, trends, etc.)

25. Calibration Test Procedure.
26. ITP (Inspection and Test Plan schedule)
27. Factory acceptance test – Procedure.
28. Calibration and Materials Test certificates (MTC)

Training Manuals.
Operator Training manuals
Engineer Training manuals.

All the documents/drawings must be submitted in ISA/ISO std. and subject to MEW approval.

C. Arrange a conference between the ICA contractor and the Engineer or his representative within sixty days after award of the Contract for the purpose of informally discussing in detail and verifying the correctness of the Telemetry, Instrumentation and Control system engineering methods and equipment and to generally provide a framework for communication and coordination. Prepare a draft of the submittal for review. The draft shall include the following, as a minimum:

D Identify items by tag number, description, function, manufacturer, model number, descriptive literature and statement as to whether item is "as specified or equivalent". Refer to the General Conditions regarding the submission of equals.

E Before proceeding with any manufacturing, submit Shop Drawings for approval in complete bound sets indexed by specification number. Describe the items being submitted. Manufacturer's specification or data sheets shall be clearly marked to delineate the options or styles to be furnished. Submit only complete systems, not pieces of equipment from various systems. Show dimensions, physical configurations, methods of connecting instruments together, mounting details, and wiring schematics. Schematics shall be complete with tag and terminal numbers. submit fabrication drawings, nameplate legends, and control panel internal wiring and piping schematic drawings clearly showing all equipment and tag numbers on all panels. Submit panel graphic drawings where applicable. Include material specifications lists where applicable. Include a draft of the theory of operation for all relay logic circuits

whether implemented via programmable controllers or relays to be included in the instruction manual required below.

F Submit an "Equipment Specification Data" form for each item of equipment which shall summarize the specification features as called for in these Specifications and include such other necessary data as would provide a complete and adequate specification for reordering an exact duplicate of the original item from the manufacturer at some future date. The assigned tag numbers and manufacturer's part numbers shall be included but will not be considered as a substitute for any of the required statement of specifications. More than one tag numbered item may be included on a sheet.

G Prepare and submit instrumentation loop diagrams for all work included in the ICM Sections in accordance with ISO and ISA std..

H Contractor shall submit reproducible of complete schematics, wiring diagrams and installation drawings to include all installed field and panel conduit and piping/tubing runs and routing, tray systems, supports, mounting details, point to point diagrams with a cable, wire, tube and termination numbers. Drawings shall be a record of work as actually constructed and shall be labeled as "Record". One copy of applicable schematics and diagrams shall be placed in each control panel in a protective envelope or binder.

I Instruction Manuals. Furnish Instruction Manuals and Part Lists for instrumentation equipment provided under the ICM Sections. Obtain distribution method instructions from the Engineer or his representative.

1. Schedule. Deliver two copies of manuals not later than the equipment shipment date. After installation is complete, update the manuals to reflect any changes which occurred during installation and deliver balance of manuals to the Engineer.

2. Format. Use drawings and pictorials to illustrate the text to the extent necessary to insure a clear, concise presentation. if manuals have been written to cover a family of similar instruments or equipment, strike out inapplicable information in a neat fashion or emphasize applicable portion by heavily weighted arrows, circles or boxes; whichever provides the clearest and neatest presentation. Where identical instruments are used in more than one control loop or subsystem, include only one instruction manual, however, an index by tag number for all instruments shall identify its location in that manual.

   Control loop and/or subsystem operational descriptions shall identify the function of each instrument and its relation to the other instruments in the loop.

3. Binding. Bind each manual in a cover which indicates the system name, manufacturer's name, local address and telephone number, and year of purchase. Punch and bind manuals in standard three ring binders and include system name and ICM Subcontractor's name on binding.

J The ICM Subcontractor, shall submit a certified report for each control panel and associated field instruments certifying that the equipment (1) had been properly installed under his supervision, (2) is in accurate calibration, (3) was placed in operation in his presence, (4) has been checked, inspected, calibrated and adjusted as necessary, (5) has been operated under maximum power variation conditions and operated satisfactorily, and (6) is fully covered under the terms of the guarantee.

K Demonstration and Final Operating Test Plans and Results. Submit for approval not later than 30 days prior to the test demonstration, a written plan for demonstrating that each system of equipment provided under the ICM Sections meets the specified operational requirements. The plan shall include procedures to be used in final operation testing of entire systems including a description for each system of test methods and materials, testing instruments and recorders, a list of the equipment involved with the functional parameters to be recorded on each item, and shop drawings of required temporary by-passes and like facilities. Submit three copies of test results and records for all final operation tests.

1.05 Product Delivery, Storage and Handling

Box, crate, or otherwise enclose and protect instruments and equipment during shipment, handling, and storage. Keep all equipment dry and covered from exposure to weather, moisture corrosive liquids and gases or any element which could degrade the equipment. Protect painted surfaces against impact, abrasion, discoloration, and other damage. Repair any damage as directed and approved.

1.06 Job Conditions

Drawings are diagrammatic and show the intended arrangement for system operation, piping, and appurtenances. Conform to Drawings as closely as possible and exercise care (1) to secure neat arrangement of piping, valves, conduit, and like items, and (2) to overcome structural interferences. Verify dimensions and conditions at the place of work, and install materials and equipment in the available spaces.

1.07 Warranty

A. Warranties and guarantees by the suppliers of various components in lieu of single-source responsibility by the equipment manufacturer will not be accepted. The equipment manufacturer shall be solely responsible for the warranty and guarantee. In the event a component fails to perform as specified or is proven defective in service during the warranty period.

B. The Contractor shall furnish the Employer with manufacturer's guarantee and warranty certificates for all equipment, duly registered with the manufacturer.

1.08 Accessory and Maintenance Manuals;

A Furnish the following items as specified herein. Deliver to the Engineer, as directed, with itemized list in a letter of transmittal accompanying each shipment.

B Furnish special tools, instruments, and accessories for maintaining instruments and equipment requiring periodic repair and adjustment as specified elsewhere herein. Also, furnish special lifting and handling devices for equipment requiring such devices.

C Deliver in manufacturer's original containers labeled to completely describe contents and equipment for which it is furnished. Spare parts shall be sufficient for years of normal service and shall include, as a minimum, the following basic items:

1. Five percent but not less than one minimum of each type of plug-in unit, etched or printed circuit board assembly.
2. Ten percent but not less than one of each type relay and timer used.
3. Ten percent but not less than one of each type switch used.

4. Ten percent but not less than six of each type light bulb and fuse used.
5. Minimum of two years supply of expendable items, diskettes, toner cartridges etc.

Part 2 Products

2.01 Materials and Standard Specifications

Provide instruments, equipment and materials suitable for service conditions and meeting standard specifications such as IEC, ANSI, ASTM, ISA, ISO, and BS. The intent of this Specification is to secure instruments and equipment of a uniform quality and manufacture throughout the plant; i.e., all instruments in the plant, supplied by the ICM contractor, of the same type shall be by the same manufacturer. This allows the stocking of the minimum number of spare parts.

2.02 Structural Steel Fabrications

Design all fabrications for dynamic and vibratory loadings. Use structural steel shapes conforming to ASTM A36, A500, A501, A570, A618, or equal and approved, as applicable. Conform welding to AWS D2.0 Code. Galvanize specific items in accordance with ASTM A123 or A386 as applicable; use galvanized bolts and fasteners with galvanized assemblies. Use minimum 6 mm thickness for steel entirely or partially submerged during equipment operation. Submit design calculations showing adequate structural integrity for the intended purpose.

2.03 Mountings

A Mount and install equipment as indicated. Where not shown, mount field instruments according to best standard practice on pipe mounts, pedestal mounts, or other similar means in accordance with supplier's recommendation. Where mounted in control panels, mount according to requirements of that Section.

B Equipment specified for field mounting shall be suitable for direct pipe mounting, pedestal mounting, or surface mounting and non in-line indicators and equipment with calibration adjustments or requiring periodic inspection shall be mounted not lower than 900 mm nor higher than 1500 mm above walkways, platforms, catwalks, etc. All such equipment shall be weather and splash proof, and electrical equipment shall be in NEMA 4 cases. External equipment shall be protected from direct sunlight by a well ventilated cabinet, canopy or other type of sunshade. If mounted in a designated hazardous area, the equipment shall be explosion proof or rated intrinsically safe, whether so specified herein or not.

C The equipment shall be guaranteed suitable for operation under the environmental conditions specified in Section 2.06 and shall be designed:-
   1) Such that routine and occasional maintenance throughout its life shall be a practical minimum compatible with the preservation of maximum reliability.
   2) To withstand the electrical, mechanical, thermal and atmospheric stresses to which it may be subjected under operational conditions, without deterioration or failure.
   3) Constructed to the highest available standards of manufacture, reliability, accuracy and repeatability.

D The degree of protection for equipment enclosures shall be in accordance with NEMA or BS EN 60529, IEC 529 or other approved equivalent standard.

F The Materials as specified in the Project specification for stainless steel material grade to be SS316L.

2.04 Instrument Identification

All major instrumentation and equipment items or systems specified in the ICM Sections are identified by system and tag numbers. This same number appears in the tag number designations on the Drawings and on the schedules of these Specifications. All instrumentation and equipment shall be identified by nameplates and/or tags. Nameplates for panels and panel mounted equipment shall be as specified under Panels and Control Room Hardware. Field equipment shall be tagged with assigned instrumentation tag number and function. Tags shall be black lamacoid with engraved white characters of 5 mm minimum height. Tags shall be attached to equipment with a commercial tag holder using a stainless steel band with a worm screw clamping device or by a holder fabricated with standard hose clamps and meeting the same description. In some cases where this would be impractical, use 20 gage stainless steel wire. For field panels or large equipment cases use stainless steel screws, however, such permanent attachment shall not be on an ordinarily replaceable part. In all cases the tag shall be plainly visible to a standing observer. In addition to tags, field mounted control stations, recorders or indicators shall have a nameplate indicating their function and the variable controlled or displayed. Nameplate shall be attached by one of the above methods.

2.05 Electronic Equipment

If the equipment is electronic in nature, provide solid state equipment to the extent practicable. Select components of construction for their suitability and reliability. Employ adequate component derating to preclude failures because of transients and momentary overloads reasonably expected in normal operation. Design units for operation without forced cooling, unless such cooling is an integral part of the device. Provide protection on all relevant circuits and equipment against the effects of lightning and other induced voltages.

2.06 Equipment Operating Conditions

All equipment shall be rated for normal operating performance with varying operating conditions over the minimum specified ranges.

2.07 Power Supplies

Provide electrical instruments, transmitter power supplies and control devices for operation on 230 Vac, 50 Hz current and as per MEW std. Transmitter power supplies shall be provided for individual transmitters. Process critical instruments shall receive power from a UPS.

2.08 Signal Isolators, Converters and Conditioners

Insure that input-output signals of all instruments and control devices are compatible. Unless otherwise specified signals between field and panels shall be 4 to 20 mA dc unless specifically approved otherwise. Granting such approval does not relieve the contractors from the compatibility requirement above. Provide signal isolators and converters as necessary to obtain the required system performance. Mount the devices behind control panels or in the- field at point of application.

2.09 Auxiliary Contacts by Others

Provide instruments and equipment to connect to auxiliary contacts provided by others for alarms, status of equipment, interlocking, and other functions as indicated and as specified herein.

2.10 Air Supply Valves

Provide 316 stainless steel valves for instrument air supply shutoff, regulating, switching, metering, valve manifolds, etc.

2.11 Instrument Piping

Provide instrument air and instrument pneumatic piping, as specified in other Divisions and as necessary and/or as specified herein. Instrument air header shall be furnished and installed under other Divisions. Connect to main instrument air header at a point not more than 3 m distant from air consuming device(s). Use 10 mm minimum 316L stainless steel tubing. All connections to equipment shall be made with separable or union type fittings and shall include shut-off valves. All hydraulic and/or pneumatic piping shall be tested for leaks prior to placing the system in operation. Provide instrument pneumatic air fittings, with double ferrules.

2.12 Filter Regulator

Furnish a filter-regulator and discharge pressure gage furnished with a dripwell assembly for each point of use where regulated instrument air is required. Separate regulators shall be used for each control loop.

2.13 Manifolds

Furnish an integral three-valve manifold for each differential pressure transmitter on a flow application.

2.14 Painting

Provide factory paint for all instruments and equipment except where in pipelines. Provide paint as per Mfr. Std. for structural supports, brackets, etc.

2.15 Electrical

A. The construction work shall include all the power supply wiring, instrumentation wiring, interconnecting wiring and equipment grounding as indicated, specified and required as per Elect. Std.

B. Wiring installations shall include cables, conductors, terminals connectors, wire markers, conduits, conduit fittings, supports, hardware and all other required materials not specifically included in the work of other Divisions.

C. Provide the materials and complete all the required installations for equipment grounding as specified in elect of these Specifications indicated on the Electrical Drawings or necessary to complete the Work.

D. Incidental items, not specifically included in the Contract Documents, that can legitimately and reasonably be inferred to belong in the instrumentation work shall be provided by the ICM Subcontractor.

E. Field Wiring. Ring out signal wiring prior to termination. Provide wire number tags marked in indelible waterproof form of slip-on type or equal for each termination. Provide pre-insulated crimp-on connectors for wire terminations and splices. Use ratchet type crimping tool which does not release until proper crimp pressure has been applied.

2.16 Process Connections

Piping, tubing, and capillary tubing shall be 316L stainless steel. If this material is unsuitable for ambient or process conditions, piping and tubing shall be of a material approved by the Engineer. Slope lines according to service to promote self draining or venting back to the process. Terminate connection to process lines or vessels in a service rated block valve, that will permit closing off the sense line or removal of the element without requiring shut down of the process. Include drip legs and blow-down valves for terminations of sense lines at the instruments when mounted such that condensation can accumulate. Process vessels, line penetrations, connecting fittings, and block valves shall be furnished and installed under other Divisions of these Specifications but coordinated by the ICM Sections. Instrument process taps shall be a minimum 18 mm NPT except flow meter taps which shall be 12 mm NPT.

Part 3 Execution

3.01 Inspection

Inspect each instrument and piece of equipment for damage, defects, completeness, and correct operation before installing. Inspect previously installed related work and verify that it is ready for installation of instruments and equipment.

3.02 Preparation

Ensure that installation areas are clean and that concrete or masonry operations are completed prior to installing instruments and equipment. Maintain the areas in a broom clean condition during installation operations.

3.03 Factory testing of Control Panels

Verify, at the factory, wiring continuity and verify panel operation by simulated inputs and outputs. Provide report certifying the control panels are operable and meet the Specifications.

3.04 Manufacturer's Installation and Supervision

When specified elsewhere in the Sections and furnish the services of authorized factory personnel especially trained and experienced in the installation of the equipment to: (1) supervise the installation in accordance with the approved Instruction Manual; (2) be present when the instruments and equipment are first put into operation; (3) inspect, check, adjust as necessary, and approve the installation; (4) calibrate the instruments, in accordance with the Specifications herein, until all trouble or defects are corrected and the installation and operation are acceptable; and (5) prepare and submit the specified Manufacturer's Certified Report. Include all costs for representative's services in the Contract Price.

3.05 Instrument Calibration

Provide the services of trained and experienced instrumentation technicians, tools and equipment to field calibrate each instrument to its specified accuracy in accordance with the manufacturer's specifications and instructions for Calibration. Each instrument shall be calibrated at 10 percent, 50 percent and 90 percent of span using test instruments to simulate inputs and read outputs that are rated to an accuracy of at least 5 times greater than the specified accuracy of the instrument being calibrated. Such test instruments shall have accuracies traceable to the National Bureau of Standards, as applicable. Provide a list and basic specifications for instruments used. Provide a written report to the Engineer on each instrument certifying that it has been calibrated to its published specified accuracy. This report shall include all applicable data as listed below plus any

defects noted, correction action required, and correction made. Data shall be recorded on prepared forms and shall include not less than the following items:

1. Facility identification (Name, location, etc.)
2. Loop identification (Name or function)
3. Equipment tag and serial numbers.
4. Scale Ranges and units.
5. Test mode or type of test.
6. Input values or settings.
7. Expected outputs and tolerances.
8. Actual readings.
9. Explanations or special notes as applicable.
10. Tester's certification with name and signature.

3.06 System Validation

A Provide the services of trained and field experienced instrumentation engineer(s) to validate each system to verify that each system is operational and performing its intended function within system tolerance. System tolerance is defined as the root-mean-square sum of the system component published specified accuracies from input to output. Validate each system by simulating inputs at the first element in loop (i.e. sensor) of 10 percent, 50 percent and 90 percent of span, or on/off and verifying loop output devices (i.e. recorder, indicator, alarm, etc. except controllers). During system validation, make provisional settings on levels, alarms, etc. Verify controllers by observing that the final control element moves in the proper direction to correct the process variable as compared to the set point. Verify that all logic sequences operate in accordance with the specifications.

B Cause malfunctions to sound alarms or switch to standby to check system operation. Check all systems thoroughly for correct operation. Test equipment for this function shall be as specified under "Instrument Calibration".

C Immediately correct all defects and malfunctions' disclosed by tests. Use new parts and materials as required and approved and retest. Provide a report certifying completion of validation of each instrument system. This report shall indicate calculated system tolerances, data verifying that the system meets these tolerances, and any provisional settings made to devices. Data sheets shall be similar to those used for Calibration.

3.07 Final Operational Testing and Acceptance

A Upon completion of instrument calibration and system validation, test all systems under process conditions. The intent of this test is to demonstrate and verify the operational interrelationship of the instrumentation systems. This testing shall include, but not be limited to, all specified operational modes, taking process variables to their limits (simulated or process) to verify all alarms, failure interlocks, and operational interlocks between systems and/or mechanical equipment.

B Immediately correct defects and malfunctions with approved methods and materials in each case and repeat the testing. Upon completion of final operational testing, submit certified report, with substantiating data sheets, indicating that total ICM System meets all the functional requirements specified herein. The Engineer will countersign this report and it shall constitute final acceptance of the ICM System.

C Testing shall be observed by the Engineer. Notify the Engineer in writing a minimum of 48 hours prior to the proposed data for commencing the test. Upon completion of this test the Contractor shall begin or have begun system start-up. The Employer reserves the right to set the schedule.

3.08 Start-up Assistance

When specified elsewhere in Sections and provide the services of a factory trained and field experienced instrumentation engineer to assist the Employer personnel during startup of the system. Purpose of this assistance is to support in making final adjustments of settings on the instrument systems.

3.09 Instruction of the Employer's Personnel

Provide the services of a trained and field experienced instrumentation engineer to conduct group training of the Employer designated personnel in the operation of each instrument system. This training shall be for a minimum time period of 7 days, one day of which may be performed during the operational testing period. Obtain the Engineer's written consent that the training has been adequate. Include instruction covering basic system theory, operating principles and adjustments, routine maintenance and repair, and "hands on" operation. The text for this training shall be the single line loop system drawings (P&ID's/I-Drawings) and operation and maintenance manuals furnished under these Specifications.

3.10 Quality Control and Training Program

A. The Employer has designated certain pieces of equipment, electrical systems and instrumentation systems as key elements of this Project. Where such key items are identified in the individual specification sections, the Contractor and the vendor/manufacturer shall provide a quality control and training program for the Employer personnel to be held at locations overseas. The program shall be submitted to the Employer for approval and shall be designed to: obtain information regarding equipment or components proposed for the Project; witness the manufacture, assembly and testing of equipment and components for the Project; receive training in the proper operations and maintenance of the equipment and components; or for any other purposes as may be directed by the Employer. The program may be used for any of the following purposes or in any other manner required by the Employer.

1. Prior to the approval of key equipment or components for the treatment plant, the Employer may wish to visit the point of manufacture and assembly of the equipment. The Employer may also wish to inspect facilities where the equipment is in use and interview the owners and operators of the equipment to learn their experience and level of satisfaction with the equipment.

2. Following approval of shop drawings for the mechanical equipment, electrical equipment, and instrumentation systems for the Project, the Employer may wish to witness the manufacture, assembly and testing of the items. The Employer may also wish to receive additional operations and maintenance training in the use of the items.

B. The Contractor shall provide whatever assistance is requested by the Employer to develop meaningful itineraries for the program. The Contractor shall provide a bar chart. schedule showing the dates of manufacture, assembly, and testing of each major item or component of the treatment plant. The Contractor shall also provide airline and hotel information as necessary to develop program itineraries. Whenever requested in writing by an authorized representative of the Employer, the Contractor shall provide prepaid air travel, hotel accommodation, surface travel, and other advanced arrangements for the Employer

designated personnel. Airline transportation shall be, as a minimum, full fare economy class. Hotels shall be minimum 4-star following recognized grading criteria. Surface transportation shall be by rental car or similar private means. The Contractor shall also provide subsistence. The full cost of the program shall be borne by the Contractor and shall be included in the unit price of the equipment or system indicated in the individual Specification section.

C. The program shall be limited to a maximum of five designated members of the Employer's staff and for a maximum duration of six months, with an average of two weeks allocated for each key element of the program. A goal of the program shall be to achieve a continuos itinerary in a logical progression of destinations, rather than as a series of individual trips.

END OF SECTION

Government of State of Kuwait
Ministry of Electricity and Water

Section 4C.3

Sequence of Operation

Contents Summary

Section 4F.2
Sequence of Operation

Part 1 General

1.01 General Reference

A This Section describes specifically the Instrumentation, Control and Monitoring System (ICM). It is the intent of this Section to supplement, where applicable, other parts of Sec.4F Divisions and to describe briefly in each main system in order to the installation contractor, as well as suppliers of packaged systems and subsystems, shall be aware of the magnitude of the total ICM System. Interfacing with all systems is a part of the work of this Section.

B Instrumentation and Control Philosophy. The instrumentation and control equipment for the works as described herein, is based on providing sufficient indication and/or automatic control to enable process operation within the design criteria. Automatic control loops are specified only where necessary and include manual bypass control options. Adequate monitoring equipment is specified to permit complete process operational management and evaluation and for operator protection.

C The overall ICM system shall provide instrumentation hardware and software as necessary to perform control functions specified herein and shown on the Drawings. Ensure coordination of instrumentation manufacturer with other work so that necessary wiring, conduits, contacts, relays, converters and incidentals are provided in order to transmit, receive, and control necessary signals to other control elements, control panels and receiving stations.

D The Specifications include functional descriptions of the process instrumentation and control systems which specify the responsibility of the ICM Systems Suppliers. These descriptions are to supplement the P&ID - Drawings and neither is complete without the other. If devices other than shown on the Drawings and/or specified herein are required to achieve the result required by the system description, these devices shall be provided to obtain the required result. The system descriptions herein cover all processes in general even though no specific ICM work may be required in a given system. These descriptions are provided for completeness and to indicate the relationships of the ICM work to other divisions. The control loop descriptions are not intended to be an inclusive listing of all elements and appurtenances required to execute loop functions and shall not be considered equal to a bill of materials.

E The Drawings and system descriptions are divided by system designations as shown on the Drawings. All equipment numbers using these designations and systems are described in the indicated order.

1.02 Description of Work

A Except when specifically described otherwise, all motors specified for automatic operation shall be provided with HAND –L/R, MANUAL- AUTO (HA) selector switches on local control panels to be installed in local control rooms and with remote position on local panels to be installed adjacent to motors. In the HAND position, the motor shall operate continuously when its START/OPEN switch is actuated and automatic interlock, if any, shall be by-passed. In the AUTO position, the motor shall be dependent on the

status of the output contact of the control circuit to be described for the individual equipment, which may originate from the DCS local control logic commands will be initiated by manually software control routine generated requests.

B When an item of equipment is selected as Remote, using the LOCAL REMOTE (L/R) switch located on the local panel, commands will be generated from the DCS. Commands will be initiated either by manually entered or software control routine generated requests.

C When specified for automatic standby, motors in multiple unit systems shall also be provided with either a DUTY-STANDBY (D/S) selector for automatic motors with HA switches or START/STOP (S/S) switches for manually operated motors without HA switches. Automatic motors with selectors on AUTO and DUTY shall be controlled by the automatic control circuit, those selected for AUTO and STANDBY shall operate only if a DUTY motor fails to respond. The standby function shall be inoperative when the HA selector is in HAND. For manually operated motors with start-stop (S/S) switches, motors selected for STANDBY shall operate if a motor selected for HAND fails to operate.

D Any lockout stop switch (LOS) associated with operating equipment shall be utilized to stop the equipment on an emergency basis only and shall not permit operation in any mode until the switch is physically reset. Whenever a LOS switch is actuated an alarm signal shall be transmitted to the auxiliary relay panel where the stopped equipment shall be identified. In the case of any conveyor or other operating equipment with exposed moving parts the LOS switch shall be replaced with a lanyard type safety switch (HSS) which extends around the perimeter of the equipment. This device shall allow actuation of the switch from any position around the equipment. Whenever a HSS switch is actuated an alarm signal shall be transmitted to the auxiliary relay panel where the stopped equipment shall be identified.

E LCP displays designated as “OA” shall indicate a failed alarm when an overload trip has occurred at a motor starter. An overload trip shall require reset at the LCP.

F HAND -AUTOMATIC switches which are located at various pieces of equipment or at the MCC shall be provided with additional contacts connected to the DCS for indication to the operator that the equipment has been placed in either the AUTO or REMOTE mode. Equipment running status shall be indicated at all local control panels (LCP) and equipment manufacturer furnished unit control panels (UCP) as well as at the central supervisory PC monitor. Motor running status of all open-close gates or valves shall be indicated at the central supervisory PC monitor as “in transition” by utilizing the position limit switches to deduce that the valve is neither opened or closed. All excess torque switches (WSH) shall be connected to the central supervisory PC monitor where a high torque alarm (WAH) or failed alarm shall be displayed.

1.03 Applicable Standards

ISO3511 Process Measurement Control Functions - Instrumentation Symbolic Representation

1.04 Quality Assurance

As per ISO latest std.

1.05 Submittals

Secure from the ICM manufacturer and include with submittals, control loop descriptions for each loop in the system. Ensure that tag numbers cross reference with loop diagrams and tag numbers shown on instrument specification forms. Describe each element and include appropriate tag number in parenthesis. When additional elements are necessary, use and assign tag number not in conflict with others and in accordance with ISO procedures.

Part 2 Products – as per the technical spec.

Part 3 Execution

The execution of the system is described in the Particular Specifications

End of Section

Government of State of Kuwait
Ministry of Electricity and Water

Section 4C.4

Technical Specification for

Monitoring Devices

Contents Summary

Monitoring Devices

Part 1 General

1.01 Description

This Section specifies primary elements of process instrumentation, auxiliary equipment and supplies directly related to the installation an operation of these primary elements, to perform the required functions in conjunction with information and equipment specified in other ICM Sections.

1.02 Quality Assurance

A. In addition to requirements of Sections, instrumentation and controls equipment furnished shall be manufactured by a firm regularly and currently engaged in the design and manufacture of similar equipment. All equipment furnished shall be new and of current design.

B. All equipment shall be designed for ease of maintenance and repair, and access to critical parts shall not require a major disassembly. Internal field adjustments where permitted or required herein shall be easily accessible upon removal of a panel or cover.

C. Materials and Installation shall comply with the requirements of the current editions of referenced electrical codes and standards, and the codes and standards referred to shall be used for establishing the minimum quality of the materials and equipment supplied and installed. All equipment of the same type shall be products of the same manufacturer. Capacities of all equipment shall not be less than that indicated on the Drawings or specified.

1.03 Submittals

A. Manufacturer's literature, illustrations, specifications and engineering data including: dimensions, actual weight, performance data and curves showing overall pump efficiencies, flow rate, head, brake horsepower, motor horsepower, speed and shut-off head. Shop drawings showing: fabrication, assembly, installation and wiring diagrams.

Part 2 Products

2.01 Electromagnetic Flow meters

A. General:

1. Magnetic flowmeters shall use electromagnetic induction to produce a dc voltage proportional to the liquid flow velocity and shall feature absolute zero stability and noise elimination. The meters shall have automatic zero correction.

2. The flow meters shall comply with standards and recommended practices of ISO 6817. Local indicators shall be supplied with all panel and surface mounted local indicators. Integral converters shall have wall or pedestal mounted local indicators. Flowmeters shall be provided with a recorder and replaceable power pack capable of lasting for more than one year.

3. Manufacturer shall calibrate and test the flow meters and provide certificates.

4. Overall accuracy better than + 0.2 percent throughout the operating range when the velocity is within 0.3 m/s to 10 m/s.

B. Sensor:
1. Flanged NP 16 process connection (Details refer to Piping and Mechanical specification)

2. Stainless steel 316L, Body, metering tube and flanges

3. Stainless steel 316 L electrodes

5. Stainless steel 316 L earthing ring or electrode

6. Lining material suitable for withstanding abrasion of the fluid

7. Enclosure fully submersible, protected to IP 68 and IP 65 for a sensor and a transmitter respectively

8. Sensor/transmitter cable to be fitted and potted by manufacturer. Screened and armored cable shall be used.

C. Transmitter
1. Remotely installed from sensor

2. 240 Vac 50 Hz power supply unless otherwise specified.

3. Inbuilt flow rate and total flow display

4. Isolated output (4-20Ma), smart type with hart protocol.

5. Inbuilt empty pipe detection including any fault in the system shall be indicated immediately via a transistor and alarm

6. Programmable range and engineering units

7. Two inbuilt relays for alarm

2.02 Rota meters – <Not applicable for this project>

1. Borosilicate glass metering tube

2. Stainless steel 316 float

3. Stainless steel 316 wetted parts and housing

4. Scale with black markings on white background, nominal length 250 mm, graduations in units specified in the schedule.

5. Flanged connection with rear inlet and outlet

6. Easy access shall be available to the glass tube for cleaning

7. ± 0.075% accuracy

8. Range ability of 10:1

2.03 Thermal Dispersion Mass Flowmeters and Flow Switches <Not applicable for this project>

1. Flow sensor shall be suitable for the measurement of air flow with a single point insertion to the process line.

2. Stainless steel 316 wetted parts

3. Inbuilt Temperature compensation

4. 230 Vac 50 Hz power supply

5. IP65 enclosure

6. 4-20 mA dc output isolated from sensor and power supply or DPDT relay where used as a flow switch

7. Local flow rate indicator to be calibrated in Engineering Units.

8. Overall accuracy of ± 1% of the flow rate.

9. Enclosure shall be certified intrinsically safe when used for gas flow measurement in hazardous area as indicated in schedule.

2.04 Vortex Gas Flow Transmitters and Flow Switches <Not applicable for this project>

1. Ultrasonic detection of turbulence (vortices) created by an obstruction shall be used to measure the flow velocity

2. Measurement shall be independent of process pressure and temperature variations.

3. 230 Vac 50 Hz power supply

4. Enclosure protected to IP65 and certified intrinsically safe when used for gas flow measurement in hazardous areas.

5. 4 to 20 mA dc output isolated from sensor and power supply or DPDT relay when used as a flow switch.

6. Stainless steel 316 wetted parts with NACE compliance

7. Inbuilt flow rate and total displays

8. Overall accuracy of ± 1% of flow rate.

2.05 Vane Type Flow Switches

1. Stainless steel 316 wetted parts
2. Enclosure protected to IP68 and explosion proof when specified in schedule.
3. NPT threaded process connection
4. DPDT contact magnetically actuated by the vane.

2.06 Ultrasonic Level Transmitter

A. The system shall comprise of a transducer and a transmitter as per the following specifications:-

1. The transmitter shall be certified intrinsically safe and suitable for hazardous area class 1, divisions 1, group D where specified in schedule.

2. Overall accuracy shall be better than ± 0.075% with a repeatability of ± 0.05%

B. Transducer:
1. Stainless steel 316 construction.
2. Enclosure protected to IP68
3. Inbuilt temperature compensation
4. Supplied complete with mounting accessories.

C. Transmitter:
1. Wall mounted and protected to IP65
2. Fieldbus power supply
3. Foundation fieldbus or Profibus Dp output proportional to measured level.
4. Inbuilt level indications
5. When used for open channel flow measurement as specified in schedule, the transmitter shall have inbuilt flow rate and total indications.
6. Programmable range
7. Relays for sensor failure, level and flow alarms.

2.07 Cut Throat Flumes

1. Fiberglass reinforced flumes shall be used for open channels flow measurement.
2. One piece molded with 5mm thick walls, reinforcing ribs.
3. Internal removable blocking shall be provided to prevent distortion during shipment and installation.
4. Self supporting and cast in reinforced concrete channel.

2.08 Float Level Switches

1. Stainless steel 316 float and linking rod

2. Stainless steel 316 enclosure protected to IP68 and certified explosion proof where specified in schedule.

3. Flanged process connection.

9. Contact shall be isolated from process and magnetically actuated DPDT rated 230 Vac 5A, 30 VDC IA.

2.09 Tilting Level Switches

1. Tilting level switches shall be used for solids level detection

2. NEMA 4 enclosure unless explosion proof is specified in schedule

3. Tilting ball enclosure shall be stainless steel or suitable plastic material

4. Contracts shall be rated 230 Vac, 5A. DPDT, IP68

2.10 Submersible Hydrostatic Level Transmitter <Not applicable for this project>

Submersible pressure detection type level transmitters shall be used for wet well level measurement as per the following specifications.

1. Capacitance sensor - flush diaphragm type to avoid sensor clogging.

2. Stainless steel 316 sensor protected to IP68 and certified intrinsically safe.

3. Loop powered transmitter with fieldbus power supply and output

4. Accuracy of ± 0.75% of full scale.

2.11 Pressure Gauges

Refer more details in section

1. 150 mm diameter dial with black markings on white background

2. Stainless steel bourdon, case and process connections.

3. ± 0.5% accuracy

4. 1/2" NPT connections

5. Complete with micrometer pointer adjustment

6. Stainless steel 316 diaphragm shall be provided when specified in schedule.

2.12 Pressure Switches;

Refer more details in section .

1. Diaphragm type sensor

2. Stainless steel enclosure certified explosion proof where specified in schedule.

3. Adjustable switching differential

4. Stainless steel 316 wetted parts

5. DPDT contact rated 240Vac 5A, 30 vdc 2A

6. Accuracy ± 0.075% of span

2.13 Pressure Transmitters
Refer more details in section

2.14 Differential Pressure Switches
Refer more details in section

1. Diaphragm type sensor

2. Stainless steel 316 wetted parts

3. Adjustable switching differential and dead band

4. Stainless steel IP68 enclosure to be certified explosion proof where specified in schedule.

5. ± 0.075% accuracy,

6. DPDT contact rated 240Vac 5A, 30 vdc, 2A, hermetically sealed.

2.15 Indicating Pressure Switches

1. Diaphragm or bellows operated for pressure or differential pressure

2. 150 mm indicating with adjustable preset pointer setting

3. DPDT contact rated 230 Vac 5A,

4. 1/2" NPT process connection

2.16 Empty Pipe Switches

1. Empty pipe detection switches shall be used for pump protection

2. Attenuation of a low frequency signal shall detect the presence of liquid.

3. DPDT contact 230 Vac 5A.

2.17 Limit Switches;

1. Limit switches shall sense position of equipment such as valves, penstocks, gates etc as specified in schedule.

2. Contacts shall be 2xDPDT as specified in schedule and rated 230 Vac 5A.

4. Enclosure shall be IP68 unless explosion proof is specified in schedule

4. Actuating mechanism and mounting shall be appropriate for the mechanical equipment being monitored.

2.18 Temperature Sensors

1. Temperature sensors shall be either a Resistance Temperature Device (RTD) or Thermocouple (TC), with duplex sensor.
2.
3. Thermocouple sensors shall be as per ANSI Standard C96.1.1964 corrected for IPTS 68

4. RTD sensors shall be of Pt 100 element per SAMA Standard RC 21-41966 corrected for IPTS 68.

4. Compensating cables shall be reused for remote temperature indications.

2.19 Bi-metal Thermometers

1. 125mm diameter adjustable angle dial

2. Stainless steel 316 thermowells

3. 1/3 pipe diameter insertion lengths

4. Ranges as indicated in schedule

5. Flanged or threaded connection generally as indicated in the plan

6. Location subject to the Engineers approval.

2.20 Gas Detection System<Not applicable for this project>

A. The system shall consist of a sensor, control module, calibration kit including sensor separation accessories and calibration gas cylinders.
B. Control Module:
   1. Rack mounted
   2. Provide audio and visual alarms when preset limits are exceeded
   3. Provide high, low and malfunction alarms.
   4. 2 or 3 digit display
   5. Output contact DPDT rated 240 Vac 2A
   6. Analog output foundation fieldbus or profibus output.
   7. Alarms to be displayed on local alarm panels and DCS

C. Oxygen Sensor:
   1. Electrochemical fuel type sensor
   2. Explosion proof enclosure
   3. O-25 percent range full scale

D. Combustible Gas Detector:
   1. Catalytic bead type sensor resistant to degradation by silicones and reduced sulfur gases.
   2. Explosion proof enclosure
   3. 0-100 LEL range full scale

E. Hydrogen Sulfide Gas Detector
   1. Solid state MOS type sensor on ceramic substrate
   2. Explosion proof enclosure
   3. 0-50 ppm range full scale

F. Chlorine Gas Detector
   1. Sensor to detect minimum concentration of 0.5 ppm
   2. 30 secs. Maximum response time for 80 percent of range to 10 ppm
   3. 3 minutes recovery time for 90 percent of range to 10 ppm

2.21 Water Quality Monitors<Not applicable for this project>

A. This section covers individual elements to measure and transmit pH, turbidity and residual chlorine. Each system shall consist of a transmitter and sensor assembly.

B. Transmitter:
   1. 240 Vac, 50 Hz power supply
   2. IP68 enclosure unless explosion proof is specified in schedule.
   3. Inbuilt digital display
   4. Isolated 4-20 mA dc output or Foundation fieldbus or profibus Dp output subject to Engineer approval.
   5. Overall accuracy of $\pm$ 0.75%

C. pH Sensor:
   1. Sensor shall measure hydrogen ion activity or oxidation reduction potential.
   2. Glass measuring electrode, reference electrode, solution ground and temperature sensor
   3. Electrolyte refill shall not be more than once a year
   4. Integral preamplifier
   5. Flow through type electrode assembly
   6. Wetted parts shall be stainless steel or plastic unless otherwise specified.
   7. Sensor shall have glass electrode and temperature compensation is required.
   8. Wash-water cleaner or ultrasonic type cleaner to be provided.

D. Residual Chlorine Sensor:
   1. Platinum cathode and anode.
   2. PH and temperature compensated
   3. 0-20 ppm range as per requirements.
   4. Flow through installation.

Part 3 Execution

3.01 Installation

Installation, testing and start-up shall be in accordance with Specifications.

3.02 Spare Parts

Spare parts for all instruments shall be provided as per particular spec and BOQ.

END OF SECTION

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Government of State of Kuwait
Ministry of Electricity and Water

Section:- 4C.5

Technical Specification for Pressure Indicating Transmitter (PIT)

Contents Summary

1 INTRODUCTION

This Specification defines the minimum requirements for the design, manufacture, supply, install, hook up, cabling, testing and commission of Pressure Transmitters to be used for Pipe line Pressure measurement for the project.

2 REFERENCE DOCUMENTS

2.1 Reference has been made, in this specification, to the latest edition of the following Codes, Standards, and Specifications:

2.1.1 Codes and Standards

BP RP 30-1	- Instrumentation & Control – Design and Practice
BP RP 30-2	- Instrumentation & Control – Selection and Use of Measurement Instrumentation
BP RP 32-1	- Inspection and Testing of New Equipment in Manufacture
BS EN 5345	- Code of Practice for Selection, Installation and Maintenance of Electrical Apparatus for Use in Potentially Explosive Atmospheres
BS EN 10204	- Metallic Products – Types of Inspection Documents
BS EN ISO 1461	Hot dip galvanized coatings on fabricated Iron and Steel articles - Specification and Test Methods.
BASEEFA	- British Approvals Services for Electrical Equipment in Flammable Atmosphere
IEC 60529	- Degrees of Protection provided by Enclosures (IP Code) IEC
60770	- Transmitters for Use in Industrial Process Control System ISO
9000	- Quality Management and Quality Assurance Standards. NACE
MR0175	- Standard Material Requirements Sulfide Stress Cracking Resistant Metallic Materials for Oilfield Equipment.

2.1.2 Project Specifications and Drawings.

2.2 Order of Precedence

In case of conflict between the requirements of this specification and the referenced codes, standards, and specifications, the following precedence shall apply:

1. This Specification.
2. Project Particular Specifications.
3. Other International Codes and Standards.

3 DEFINITIONS

To match the definitions, as specified in the spec.

4 ENVIRONMENTAL CONDITIONS

The environmental of Kuwait, is severe on all equipment and must be considered carefully before design and procurement of plant and equipment. It must be assumed that, unless otherwise specified, equipment may be subjected to sand and fine particle dust storms, sand laden winds, chemical contaminants, thunderstorms, heavy rain and extreme temperatures.

4.1 Temperature and Humidity

Summer maximum dry bulb temperature :	65°C, shade
Summer minimum wet bulb temperature :	28°C
Summer maximum average dry bulb temperature :	50°C
Summer maximum dry bulb temperature (Solar):	80°C

Soil temperature at 1.22m depth: maximum 35°C. minimum 17°C. A design of 40°C shall be used for cable system design calculations.

For electrical equipment design, ambient temperature shall be –3°C to 50°C for all indoor (inside a/c room) and outdoor equipment shall be –3°C to 85°C for the pressure transmitter with all accessories.

Except for as limited by coating on pipes, the surface design temperature (applicable) shall be 93°C for equipment and installation.

a) Direct Sunlight : Exposed metal black body maximum temperature due to solar radiation : 85°C

b) Shade Temperature : 55°C maximum
45°C average (1day)
–3°C minimum @ 100% RH

Note : All equipment and materials shall be suitable for this direct sunlight temperature unless installed in a protected environment. Sunshades shall be provided where appropriate.

c) Exposed white body maximum temperature : 65°C

d) Winter minimum dry bulb temperature : –3°C

e) Winter minimum average dry bulb temperature : 7°C

f) Winter minimum average wet bulb temperature : 3°C

Note : These dry and wet bulb temperatures shall be used for winter heating design purposes.

g) Relative humidity maximum at : 55°C, 50% at 0°C, 100% varying from 6 to 100%

4.2 Atmospheric Conditions

The atmosphere is generally dusty and corrosive and in some areas may contain traces of hydrogen sulphide.

4.3 Sandstorms

Kuwait is subject to sandstorms, particularly during the summer months:

a) Ambient air range minus –3°C to 55°C

b) 16 grams dust per 100 cubic foot air.

c)

DustParticleSize (micron)	Wt%FineDust (Plus/minus 3%)
0-5	39
5-10	18
10-20	16
20-40	18
40-80	9

4.4 Wind Data

a) Maximum recorded windspeed : 38 m/s

b) Design maximum windspeed : 45 m/s

c) Summary prevailing wind direction / speed : SE, 6 m/s (Burgan area)

d) Winter prevailing wind direction / speed : NW, 6 m/s (Burgan area)

e) Prevailing wind direction / speed : NNW, 6 m/s (North Kuwait)

f) Summer prevailing wind direction : NNW (North Kuwait)

g) Winter prevailing wind direction : SSE (North Kuwait)

4.5 Rainfall

Kuwait is subject to thunderstorms and heavy rainfall.

a) Annual maximum : 200mm.

b) 115 mm/h, falling uniformly for 30 minutes

4.6 Seismic Data

Kuwait is not subject to earthquakes, and is therefore not an active seismic zone.

5 QUALITY ASSURANCE

The MANUFACTURER shall operate a Quality System meeting the requirements of the relevant Part of ISO 9000.

The MANUFACTURER shall ensure that his sub-SUPPLIERs operate a quality system meeting the specified conformance criteria to ISO 9000. The MANUFACTURER's quality system shall be subject to the MEW's approval prior to commitment to a Purchase Order.

Major Sub-SUPPLIERs shall be subject to identical approvals. The MEW reserves the right to conduct a Quality Audit at the MANUFACTURER's/Sub-SUPPLIER's facilities at any stage during manufacture.

6 DESIGN A ND CONSTRUCTION

6.1 General

The pressure and differential pressure transmitters shall be a "Smart" type suitable for both analogue and digital simultaneous transmission using open field bus protocol and have non-volatile configuration data storage. A self-diagnostic facility shall be provided.

The system shall be an open system composed of standards-based technology with field devices over smart with HART protocol, 2 wire system, 4-20mA/24vDC.

The field-device shall connect to the DCS system via. direct hardwired to the redundant DCS I/O modules via. Signal splitter.

The pressure transmitter shall be of latest 'state-of the-art' technology using modern digital techniques for measurement, signal processing, configuration and self-diagnosis. Transmitter shall have digital display and advanced automatic programmable calibration features.

The pressure transmitter shall be of proven reliable type, five years stability and can withstand ambient / static head / surge conditions. All accessories shall be included including two way manifold, integrated digital local indication, power supply unit, cables, etc.

The transmitter's design shall guarantee long lifetime and long re-calibration intervals, have very high reliability with ease of maintenance and shall comply with the industrial standards normally followed.

6.2 Sensor

The Sensor module fill fluid shall be silicon oil and comply the following:-

Element Type	Diaphragm Type
Element Material	SS-316L (with NACE) for D.W&F.W water service and Monel for Brackish water service.
Span Limit	By Vendor
Process Connection	1/2" NPT F
Fill Fluid	Silicone Oil

6.3 Body:-

The transmitters shall have vent or drain connections in the body. They shall also have over range protection up to the maximum chamber rating on either side without temporary or permanent damage.

6.4 Transmitter:-

The transmitter shall comply the following specification:-

Type		SMART type with HART protocol
Signal Output		24v DC/4-20mA
Instrument Range	Psig	Vendor to specify
Calibration Range	Psig	As per the design.
Accuracy		+/- 0.03% of Range Span
Build in Indicator		Required, LCD Display with Engg Units
Power supply		Powered fully redundant for dual ring network and isolated DC with built-in surge protection and intrinsically safe installations.
Cable Entry		ISO M20
Electrical Connection		Screw Type Terminal
Enclosure Certification		Weather proof certification
Ingress Protection (IP)		IP68 for below ground and IP65 for above ground installations
Surge protection		Built-in Surge module
Over Range Protection		130% of full scale
Materials		
Wetted parts, body, electronic housing enclosure, drain, vent plug, cable entry, gland – materials		SS316L
Two manifold material		SS316L

6.5 Output

Transmitter output shall be both 4-20 mA with superimposed digital signal complying with open digital field bus communication HART protocol

Power supply:-
Redundant Isolated 24Vdc Power supply, loop powered.

6.6 Electronics

The transmitter electronics shall be solid-state with appropriate 'smart' circuitry. Printed circuit boards (PCB) shall be of a replaceable modular construction, be hermetically sealed or protected by a corrosion resistant coating (tropicalised). PCB shall be plug-in type and vibration free supported. Signal wiring terminals and electronics shall be housed in separate compartments, so that the electronics remain sealed during electrical connection to the signal cable.

6.7 Calibration / Configuration

It shall be possible to perform on-line and remote set point configuration/calibration of the transmitter via a Hand Held Communicator (HHC) using HART protocol. HHC shall be of easy to use and shall be suitable for use in the area classification as specified for transmitters in the related Data Sheets. The

fieldbus output of the transmitter shall not be affected during communication with the HHC.

Online Configurability

The system shall support the making of online configuration changes such as calibration, up loading and down loading the software from the Panel mount industrial PC workstations, repairs, extensions and modifications to trunk lines. And configure into maintenance management system and Asset management system.

6.8 Adjustments

The zero and span of the transmitters shall be adjusted through the Hand Held Communicator (HHC). A facility for engineering unit selection shall also be available from the HHC. The zero and span adjustments shall be non interactive and continuously adjustable.

6.9 Indication

Transmitters shall be complete with an integral digital output meter with 4 digits, LCD readout via. Hart protocol. The output meter scale shall cover the entire transmitter range of the transmitter in Engineering Units, as indicated in the related Project Data Sheet for Pressure and Differential Pressure Transmitters. In addition to the above, the digital output meter shall be provided with the facility of displaying the measured value as a percentage of the calibrated span.

6.10 Performance

The transmitter accuracy, including the combined effect of linearity, hysterisis and repeatability shall be equal to or better than 0.003%. With reference to IEC 60770, errors shall be expressed as percentage of calibrated span, unless stated otherwise.

6.11 Temperature Compensation

The transmitter electronics shall include facilities for the temperature compensation. The sensor characterisation curve shall be stored in EPROM.

6.12 Transmitter Housing

The transmitter electronics shall be field-mounted type. The transmitter enclosure shall be SS316L and shall be weather proof to IP 68 inside valve pit and IP65 for above ground installations. The transmitter shall be installed inside GRP Instrument housing (800x800x400mm, min). The price for the GRP IHB item shall be included in the respective item of transmitter bill of quantity.

No Aluminium in its un-anodised form shall be used. No copper or its alloys shall be used.

The units shall be supplied in housings suitable for environmental condition as specified in the above Section.

6.13 Wetted Parts

All wetted parts, the remote diaphragm seal shall meet the requirements of NACE MR 01-75 and shall be as specified in the related Data Sheet for Pressure and Differential Pressure Transmitters.

6.14 Cable Entry / Connection

The electrical signal cable entry shall be M20 x 1.5 ISO threaded or manufacturer std. Unused cable entries shall be plugged (SS316L-Plug) off in compliance with the specified electrical safety.

Signal wiring terminals shall be of the screw type or manufacture std. All terminals for electrical connections shall be clearly numbered. The terminals polarity, where applicable, shall be permanently marked.

NOTE: Transmitters with flying leads are not acceptable.

6.15 Hook materials:-

The hook-up and impulse tubing for the Pressure Gauge and Differential Pressure Gauge material shall be SS316L including tubes, fittings, valves, union, tee, elbow, reducer, coupling etc…

The hook –up material for the Brackish water service to be monel and compliance with NACE MR 0175.

6.16 Manifold:-

Two/three way manifold (SS316L) to be provided for the Pressure transmitter from the manufacturer as a integral part of the transmitter.

The manifold material for the Brackish water service to be monel and compliance with NACE MR 0175.

6.17 Tagging

Transmitters shall be provided with an identification plate, with all data clearly stamped on a corrosion resistant plate permanently attached to each instrument by means of rivets or pins and shall indicate, as a minimum, the following:

- Name of the MANUFACTURER or Trade Mark

- Manufacturer's Model Number
- Instrument Tag Number
- Serial Number
- Year of Manufacture
- Range & Calibration (including units of measurement)
- Body Rating (including units)
- Electrical safety (type of protection)
- Output signal

Note 1: Each transmitter shall be provided with a Certification Plate fixed with a stainless steel wire to the transmitter.

The Separate hanging SS316 tag plate of 60mm X 25mm X 1.5mm deep engraved with ink filling in Arial font shall be provided.

The Certification Plate shall carry necessary details with regard to statutory approval as follows:

i) Type of approval and mark of certifying body.
ii) Certifying authority name.
iii) License / certificate number and date
iv) Area Classification Group and Temperature Rating

6.18 Mounting Arrangements

The transmitter shall be suitable to mount on 2" pipe support (stanchion) as per the ISA std. instrument hook-up drawing.

6.19 Accessories

The process connection shall be ¾'' and flange in accordance with the related Data Sheets for Pressure and Differential Pressure Transmitters.

The transmitter shall be supplied with mounting brackets, bolt, nuts, clamps, etc. as specified in the related Data Sheets for Pressure and Differential Pressure Transmitters.

All the mounting accessories materials to be SS316L.

6.20 Painting

Where applicable, painting shall as per MANUFACTURER own standard, with MEW's approval. Stainless steel Pressure Transmitter shall not be painted.

6.21 Data sheet for Pressure transmitter:-

Process Media: Fresh Water / Brackish Water

Power Supply: Redundant Isolated 24Vdc power supply

Communication Protocol: Hart.

Cable 1px 1.5 sq.mm, as per cable data sheet

Signal Load: > 500 Ω (as per manufacture std.)

Characteristic: Linear, rising or falling

Accuracy: ± 0.03% of calibrated span

Calibration: Automatic, programmable and panel mount HMI Work station

Conformity: 0.01%

Hysteresis: 0.05%

Response time 1 ms.

Ambient Temperature : Min 3°C at100%RH, Max. 75°C(Shade) at 50%RH, Max. Radiation Black Body 85°C, white body 65°C

Process Temperature: 0°C to +65°C

Humidity: 95%, condensing

Protection: IP68 and Enclosure shall be weatherproof where specified in schedule

Repeatability ± 0.03% at maximum span

Stability ± 0.03% of span over a 12 months period

Over pressure sustain a 200% overpressure without damage

Signal output	Accuracy	Local Display	Over range protection	Housing Enclosure &Sensor materials	Hook up materials & accessories.	Enclosure certification	Certificate
4-20mA. Hart	+/- 0.03%	Builtin LCD Engineering unit configurable	200%	SS 316L	SS316L, Two way manifold, tubes, fittings and 2'' Pipe mounting with mounting bracket.	Zone.2, Gr.IIB	MTC and Calibration

The manufacturer should submit the data sheet in ISA format for MEW approval.

6.22 General:-

The transmitter shall have the following features,

i. Configuration of transmitters in online operation.

ii. Loading and saving device data (Up load/Down load)

iii. Quick and safe commissioning of the same measuring points by copying the configuration data from one transmitter to another transmitter.

iv. Simple diagnosis by recording diverse events such as alarms, configuration changes, counters for measuring range undershoot and overshoot for pressure as well as user limit overshoot and undershoot.

v. Easy and safe menu guided operation for quick setup via. local configuration using the HHC and soft pushbuttons.

One no. Hart field HHC (Hand Held Configurator) to be supplied as part of the contract requirement, the price for the HHC to be included in the respective item of the pressure transmitter BOQ.

vi. Local Display (Either integral type provided it is easily locally accessed and monitored or remote mounted):-

viii. Comprehensive diagnostic functions (Fault and warning message) and Programmable with an integral programming keypad an integral part of the transmitter.

ix. Signals on alarm:- Last valued output value, last good value, failsafe value, status bad, and wrong value

x. The mean time between failure for transducers shall be not less than 15 years, and the performance of the measurement system shall be as below or better.

7 DOCUMENTATION

7.1 Documentation Required for approval

- Full technical literature for the equipment offered.
- An unqualified statement of compliance with the specification and data sheet requirements.
- A list of all accessory items together with MANUFACTURER's name and part number.
- The VENDOR shall provide a completed copy of the instrumentation data sheets with all changes entered.
- General Arrangement / Construction Drawings
- Overall dimensions of equipment
- Design Calculations

- Material and electrical certificates
- Quality Control Manual and Quality Plan

On receipt of written approval, the MANUFACTURER shall submit to the MEW all approved documents as listed above.

Prior to shipment, the MANUFACTURER shall submit the test certificates as listed in Section 9 of this Specification.

Documents shall be in the English Language.

8 INSPECTION AN D TESTS

8.1 General

The MANUFACTURER shall meet the inspection and testing requirements of BP RP 32-1. All required inspection and testing works shall be carried out at MANUFACTURER's work prior to shipment

8.2 Factory Testing

Each transmitter shall be hydrostatically pressure tested at minimum 1.25 times the chamber rating.

For verification of NACE MR 01-75 compliance, the transmitters shall be subjected to a NACE hardness (or test sample of raw parts) on chamber parts and blind (oral) flanges but not diaphragms.

Functional / Calibration Test shall be conducted on each Pressure and Differential Pressure Transmitter.

The MEW reserves the right to require additional testing, at any time, to confirm or further investigate a suspected fault. All costs incurred shall be on the MANUFACTURER's account. In no case shall any action of the MEW, or his Inspector, relieve the MANUFACTURER of his responsibility for material, design, quality, or performance of the materials concerned. Inspection and tests performed/witnessed by the MEW's Inspector shall in no way relieve the MANUFACTURER of his obligation to perform the required inspection and tests. Inspection by the MEW's inspector shall be restricted to the following:

- Visual examination and dimensional check of the process connection
- Verification of testing as mentioned under factory testing
- Verification of type of protection certificate or declaration
- Verification of material certificates
- Verification of NACE compliance

The MEW may, at his discretion, appoint a Third Party Inspection Agency to carry out inspection on behalf of, or together with, the MEW's Inspector.

9 TEST CERTIFICATES

The MANUFACTURER shall submit the following certificates in accordance with EN10204 3.1.

a) Hydrostatic test certificates
b) Material test certificate (MIL certificate) for wetted parts.
c) Test report for class of enclosure.
d) Calibration reports for all transmitters.

The VENDOR shall supply a works certificate issued and signed by the MANUFACTURER's inspection, laboratory personnel, or other appropriate responsible employee. The inspection or other employee signing the certificate must be independent of the MANUFACTURER's production department.

The works certificate shall contain numerical results of chemical, electrical and mechanical tests. The type and extent tests shall be as described by the specification for the particular material involved.

In addition, the certificate shall include all information regarding customer, number of order, works number, type and quantity of materials. The production, process heat treatment, and other relevant features, if not limited or prescribed by the material specification should also be included

The test certificate shall confirm that satisfactory testing has been carried out. Manufacture's serial number shall be quoted on all certificates. The certificates shall indicate the method of marking and the material shall be marked in such a manner that it can be traced back to the certificate and test relevant to it.

All non-destructive testing shall be fully certified.

10 SPARE PARTS

The MANUFACTURER shall provide the recommend spare parts on the following basis:

- Commissioning spares
- Two (2) years operation spares

The commissioning and operations spares to be handed over to MEW store.

Parts data shall be listed on proper form and be supplemented with appropriate drawings / bulletins identifying all parts in their respective position".

MANUFACTURER shall provide the Standard Recommended Spare Parts list (for maintenance) form for Spare Parts and Maintenance Data.

The price for the spare parts shall be included in the respective item of the pressure transmitter BOQ.

11 PREPARATION FOR SHIPMENT

VENDOR shall be responsible for the design, supply, assembly and application of all preservation & packaging required for safe transportation, handling and storage of Pressure & Differential Pressure Transmitter supplied under this order.

All openings shall be sealed and threaded connections shall be protected with moulded plastic screwed plugs or caps. The Transmitters shall be packed in cartons

or crates, suitable for sea shipment in such a way that corrosion and damage to parts and paint is avoided.

Each individual carton or box shall be marked with the Project Name & Code, Purchase Order No., Tag No. and MEW's Name and Address, on the top and side of the carton / crate.

Initial spares shall be packed separately from the main equipment. The box or case shall be clearly marked 'Initial Spares', Project Name & Code, Purchase Order No. and Tag No. on the top and side of the carton. Furthermore each spare part shall have its part number clearly identified and attached.

VENDOR shall be entirely responsible for any claim arising, which is attributable to defective and / or insufficient packing.

Government of State of Kuwait
Ministry of Electricity and Water

SECTION 4C.6

Technical Specification for Differential Pressure Transmitter

Contents Summary

1 INTRODUCTION

This Specification defines the minimum requirements for the design, manufacture, supply, install, cabling, hook-up, testing and commissioning of Differential Pressure Transmitter used to measure the differential pressure across the Pressure reducing stations, bypass stations, etc.. as per the project specification requirements.

2 REFERENCE DOCUMENTS

2.1 Reference has been made, in this specification, to the latest edition of the following Codes, Standards, and Specifications:

2.1.1 Codes and Standards

BP RP 30-1	- Instrumentation & Control – Design and Practice
BP RP 30-2	- Instrumentation & Control – Selection and Use of Measurement Instrumentation
BP RP 32-1	- Inspection and Testing of New Equipment in Manufacture
BS EN 5345	- Code of Practice for Selection, Installation and Maintenance of Electrical Apparatus for Use in Potentially Explosive Atmospheres
BS EN 10204	- Metallic Products – Types of Inspection Documents
BS EN ISO 1461	Hot dip galvanized coatings on fabricated Iron and Steel articles - Specification and Test Methods.
BASEEFA	- British Approvals Services for Electrical Equipment in Flammable Atmosphere
IEC 60529	- Degrees of Protection provided by Enclosures (IP Code)
IEC 60770	- Transmitters for Use in Industrial Process Control System
ISO 9000	- Quality Management and Quality Assurance Standards.
NACE MR0175	- Standard Material Requirements Sulfide Stress Cracking Resistant Metallic Materials for Oilfield Equipment.

2.1.2 Project Specifications and Drawings.

2.2 Order of Precedence

In case of conflict between the requirements of this specification and the referenced codes, standards, and specifications, the following precedence shall apply:

1. This Specification.
2. Project Particular Specifications.
3. Other International Codes and Standards.

3 DEFINITIONS

To match the definitions, as specified in the spec.

4 ENVIRONMENTAL CONDITIONS

The environmental of Kuwait, is severe on all equipment and must be considered carefully before design and procurement of plant and equipment. It must be assumed that, unless otherwise specified, equipment may be subjected to sand and fine particle dust storms, sand laden winds, chemical contaminants, thunderstorms, heavy rain and extreme temperatures.

4.1 Temperature and Humidity

Summer maximum dry bulb temperature : 65°C,

shade Summer minimum wet bulb temperature : 28°C

Summer maximum average dry bulb temperature : 50°C

Summer maximum dry bulb temperature (Solar): 80°C

Soil temperature at 1.22m depth: maximum 35°C. minimum 17°C.
A design of 40°C shall be used for cable system design calculations.

For electrical equipment design, ambient temperature shall be –3°C to 50°C for all indoor (inside a/c room) and outdoor equipment shall be –3°C to 85°C for the Dp transmitter with all accessories.

Except for as limited by coating on pipes, the surface design temperature (applicable) shall be 93°C for equipment and installation.

a) Direct Sunlight : Exposed metal black body maximum temperature due to solar radiation : 85°C

b) Shade Temperature : 55°C maximum
45°C average (1day)
–3°C minimum @ 100% RH

Note: All equipment and materials shall be suitable for this direct sunlight temperature unless installed in a protected environment. Sunshades shall be provided where appropriate.

c) Exposed white body maximum temperature : 65°C

d) Winter minimum dry bulb temperature : –3°C

e) Winter minimum average dry bulb temperature : 7°C

f) Winter minimum average wet bulb temperature : 3°C

Note : These dry and wet bulb temperatures shall be used for winter heating design purposes.

g) Relative humidity maximum at : 55°C, 50% at 0°C, 100% varying from 6 to 100%

4.2 Atmospheric Conditions

The atmosphere is generally dusty and corrosive and in some areas may contain traces of hydrogen sulphide.

4.3 Sandstorms

Kuwait is subject to sandstorms, particularly during the summer months:

a) Ambient air range minus –3°C to 55°C

b) 16 grams dust per 100 cubic foot air. c)

Dust Particle Size (micron)	Wt% Fine Dust (Plus/minus 3%)

5-10	18
10-20	16
20-40	18
40-80	9

4.4 Wind Data

a) Maximum recorded windspeed : 38 m/s

b) Design maximum windspeed : 45 m/s

c) Summary prevailing wind direction / speed : SE, 6 m/s (Burgan area)

d) Winter prevailing wind direction / speed : NW, 6 m/s (Burgan area)

e) Prevailing wind direction / speed : NNW, 6 m/s (North Kuwait)

f) Summer prevailing wind direction : NNW (North Kuwait)

g) Winter prevailing wind direction : SSE (North Kuwait)

4.5 Rainfall

Kuwait is subject to thunderstorms and heavy rainfall.

a) Annual maximum : 200mm.

b) 115 mm/h, falling uniformly for 30 minutes

4.6 Seismic Data

Kuwait is not subject to earthquakes, and is therefore not an active seismic zone.

5 QUALITYASSURANCE

The MANUFACTURER shall operate a Quality System meeting the requirements of the relevant Part of ISO 9000.

The MANUFACTURER shall ensure that his sub-SUPPLIERs operate a quality system meeting the specified conformance criteria to ISO 9000. The MANUFACTURER's quality system shall be subject to the MEW's approval prior to commitment to a Purchase Order.

Major Sub-SUPPLIERs shall be subject to identical approvals. The MEW reserves the right to conduct a Quality Audit at the MANUFACTURER's/Sub-SUPPLIER's facilities at any stage during manufacture.

6 DESIGN AND CONSTRUCTION

6.1 General

The Level and differential pressure transmitters shall be a "Smart" type suitable for both analogue and digital simultaneous transmission using open field bus protocol and have non-volatile configuration data storage. A self-diagnostic facility shall be provided.

The system shall be an open system composed of standards-based technology with field devices over smart with HART protocol, 2 wire system, 4-20mA/ 24vDC.

The field-device shall connect to the Process Control Units via. direct hardwired to the redundant DCS I/O modules via. Signal splitter.

The level transmitter shall be of latest 'state-of the-art' technology using modern digital techniques for measurement, signal processing, configuration and self-diagnosis. Transmitter shall have digital display and advanced automatic programmable calibration features.

The level transmitter shall be of proven reliable type, five years stability and can withstand ambient / static head / surge conditions. All accessories shall be included including five way manifold, integrated digital local indication, power supply unit and local volume LED indicator, etc.

The transmitter's design shall guarantee long lifetime and long re-calibration intervals, have very high reliability with ease of maintenance and shall comply with the industrial standards normally followed.

6.2 Sensor

The Sensor module fill fluid shall be silicon oil and comply the following:-

Element Type	Diaphragm Type
Element Material	SS-316L (with NACE) for F.W water service
Span Limit	By Vendor
Process Connection	1/2" NPT F
Fill Fluid	Silicone Oil

6.3 Body:-

The transmitters shall have SS316L vent or drain connections in the body. They shall also have over range protection up to the maximum chamber rating on either side without temporary or permanent damage.

6.4 Transmitter:-

The transmitter shall comply the following specification:-

Type		SMART type with HART protocol
Signal Output		24v DC/4-20mA
Instrument Range	Psig	Vendor to specify
Calibration Range	Psig	As per the design.
Accuracy		+/- 0.03% of Range Span
Build in Indicator		Required, LCD Display with Engg Units
Power supply		Redundant Isolated 24Vdc power supply unit from PCU panel
Cable Entry		ISO, M20
Electrical Connection		Screw Type Terminal
Enclosure Certification		Weather proof certification
Ingress Protection (IP)		65
Surge protection		Built-in Surge module
Over Range Protection		130% of full scale
Materials		
Wetted parts, body, electronic housing enclosure, drain, vent plug, cable entry, gland – materials		SS316L
Five way manifold material		SS316L

The level and differential pressure transmitter shall be installed inside GRP Instrument housing (800x800x400mm, min). The price for the GRP IHB item shall be included in the respective item of transmitter bill of quantity.

6.5 Output

Transmitter output shall be both 4-20 mA with superimposed digital signal complying with open digital field bus communication HART protocol

Power supply:-

Redundant Isolated 24Vdc Power supply, loop powered.

6.6 Electronics

The transmitter electronics shall be solid-state with appropriate 'smart' circuitry. Printed circuit boards (PCB) shall be of a replaceable modular construction, be hermetically sealed or protected by a corrosion resistant coating (tropicalised). PCB shall be plug-in type and vibration free supported. Signal wiring terminals and electronics shall be housed in separate compartments, so that the electronics remain sealed during electrical connection to the signal cable.

6.7 Calibration / Configuration

It shall be possible to perform on-line and remote set point configuration/calibration of the transmitter via a Hand Held Communicator (HHC) using HART protocol. HHC shall be of easy to use and shall be suitable for use in the area classification as specified for transmitters in the related Data Sheets. The fieldbus output of the transmitter shall not be affected during communication with the HHC.

Online Configurability

The system shall support the making of online configuration changes such as calibration, up loading and down loading the software from the DCS workstations, repairs, extensions and modifications to trunk lines. And configure into maintenance management system and Asset management system.

6.8 Adjustments

The zero and span of the transmitters shall be adjusted through the Hand Held Communicator (HHC). A facility for engineering unit selection shall also be available from the HHC. The zero and span adjustments shall be non interactive and continuously adjustable.

6.9 Indication

Transmitters shall be complete with an integral digital output meter with 4 digits, LCD readout via. Hart protocol. The output meter scale shall cover the entire transmitter range of the transmitter in Engineering Units, as indicated in the related Project Data Sheet for Pressure and Differential Pressure Transmitters. In addition to the above, the digital output meter shall be provided with the facility of displaying the measured value as a percentage of the calibrated span.

6.10 Performance

The transmitter accuracy, including the combined effect of linearity, hysterisis and

repeatability shall be equal to or better than 0.03%. With reference to IEC 60770, errors shall be expressed as percentage of calibrated span, unless stated otherwise.

6.11 Temperature Compensation

The transmitter electronics shall include facilities for the temperature compensation. The sensor characterisation curve shall be stored in EPROM.

6.12 Transmitter Housing

The transmitter electronics shall be field-mounted type. The transmitter enclosure shall be SS316L and shall be weather proof to IP 68 inside valve pit and IP65 for above ground installations. The transmitter shall be installed inside GRP Instrument housing (800x800x400mm, min). The price for the GRP IHB item shall be included in the respective item of transmitter bill of quantity.

No Aluminium in its un-anodised form shall be used. No copper or its alloys shall be used.

The units shall be supplied in housings suitable for environmental condition as specified in the above Section.

6.13 Wetted Parts

All wetted parts, the remote diaphragm seal shall meet the requirements of NACE MR 01-75 and shall be as specified in the related Data Sheet for level Transmitters.

6.14 Cable Entry / Connection

The electrical signal cable entry shall be M20 x 1.5 ISO threaded or manufacturer std. Unused cable entries shall be plugged (SS316L-Plug) off in compliance with the specified electrical safety.

Signal wiring terminals shall be of the screw type or manufacture std. All terminals for electrical connections shall be clearly numbered. The terminals polarity, where applicable, shall be permanently marked.

NOTE: Transmitters with flying leads are not acceptable.

6.15 Hook materials:-

The hook-up and impulse tubing for the level transmitters material shall be SS316L including tubes, fittings, valves, union, tee, elbow, reducer, coupling etc…
The wetted parts on the hook up material shall compliance with NACE MR 0175.
The level transmitter shall be installed inside GRP Instrument Housing Box.

The hookup piping shall be routed from the the Bottom of the tower via. 3'' SS316L Pipe with proper adequate SS316L support angle and clamps with required accessories.

6.16 Manifold:-

Five way manifold (SS316L) to be provided for the level transmitter from the manufacturer as a integral part of the transmitter.

The manifold wetted parts material shall compliance with NACE MR 0175.

6.17 Tagging

Transmitters shall be provided with an identification plate, with all data clearly stamped on a corrosion resistant plate permanently attached to each instrument by means of rivets or pins and shall indicate, as a minimum, the following:

- Name of the MANUFACTURER or Trade Mark
- Manufacturer's Model Number
- Instrument Tag Number
- Serial Number
- Year of Manufacture
- Range & Calibration (including units of measurement)
- Body Rating (including units)
- Electrical safety (type of protection)
- Output signal

Note 1: Each transmitter shall be provided with a Certification Plate fixed with a stainless steel wire to the transmitter.

The Separate hanging SS316 tag plate of 60mm X 25mm X 1.5mm deep engraved with ink filling in Arial font shall be provided.

The Certification Plate shall carry necessary details with regard to statutory approval as follows:

i) Type of approval and mark of certifying body
ii) Certifying authority name.
iii) License / certificate number and date
iv) Area Classification Group and Temperature Rating

6.18 Mounting Arrangements

The transmitter shall be suitable to mount on 2" pipe support (stanchion) as per the ISA std. instrument hook-up drawing.

6.19 Accessories

The process connection shall be ¾'' and flange in accordance with the related Data Sheets for level transmitters

The transmitter shall be supplied with mounting brackets, bolt, nuts, clamps, etc. as specified in the related Data Sheets for level transmitters.

All the mounting accessories materials to be SS316L

6.20 Painting

Where applicable, painting shall as per MANUFACTURER own standard, with MEW's approval. Stainless steel Level Transmitter shall not be painted.

Signal output	Accuracy	Local Display	Over range protection	Housing Enclosure &Sensor materials	Hook up materials & accessories.	Enclosure certification	Certificate
Smart, with Hart protocol 4-20mA, 24vDC	+/- 0.03%	Builtin LCD Engineering unit configurable	200%	SS 316L	SS316L, five way manifold, tubes, fittings and 2'' Pipe mounting with mounting bracket.	Zone.2, Gr.IIB	MTC and Calibration

The manufacturer should submit the data sheet in ISA format for MEW approval.

6.22 General:-

The transmitter shall have the following features,

i. Configuration of transmitters in online operation.

ii. Loading and saving device data (Up load/Down load)

iii. Quick and safe commissioning of the same measuring points by copying the configuration data from one transmitter to another transmitter.

iv. Simple diagnosis by recording diverse events such as alarms, configuration changes, counters for measuring range undershoot and overshoot for pressure as well as user

limit overshoot and undershoot.

v. Easy and safe menu guided operation for quick setup via. local configuration using the HHC and soft pushbuttons.

One no. Hart field HHC (Hand Held Configurator) to be supplied as part of the contract requirement, the price for the HHC to be included in the respective item of the pressure transmitter in the BOQ.

vi. Local Display (Either integral type provided it is easily locally accessed and monitored or remote mounted):-

viii. Comprehensive diagnostic functions (Fault and warning message) and Programmable with an integral programming keypad an integral part of the transmitter.

ix. Signals on alarm:- Last valued output value, last good value, failsafe value, status bad, and wrong value

x. The mean time between failure for transducers shall be not less than 15 years, and the performance of the measurement system shall be as below or better.

7 DOCUMENTATION

7.1 Documentation Required for approval

- Full technical literature for the equipment offered.
- An unqualified statement of compliance with the specification and data sheet requirements.
- A list of all accessory items together with MANUFACTURER's name and part number.
- The VENDOR shall provide a completed copy of the instrumentation data sheets with all changes entered.
- General Arrangement / Construction Drawings
- Overall dimensions of equipment
- Design Calculations
- Material and electrical certificates
- Quality Control Manual and Quality Plan

On receipt of written approval, the MANUFACTURER shall submit to the MEW all approved documents as listed above.

Prior to shipment, the MANUFACTURER shall submit the test certificates as listed in Section 9 of this Specification.

Documents shall be in the English Language.

8 INSPECTION AND TESTS

8.1 General

The MANUFACTURER shall meet the inspection and testing requirements of BP RP 32-1. All required inspection and testing works shall be carried out at MANUFACTURER's work prior to shipment

8.2 Factory Testing

Each transmitter shall be hydrostatically pressure tested at minimum 1.25 times the chamber rating.

For verification of NACE MR 01-75 compliance, the transmitters shall be subjected to a NACE hardness (or test sample of raw parts) on chamber parts and blind (oral) flanges but not diaphragms.

Functional / Calibration Test shall be conducted on each Level Transmitter.

The MEW also reserves the right to witness tests as indicated above, at the MANUFACTURER's works, prior to shipment. The MANUFACTURER shall give reasonable notice of date and time for such inspection and shall provide reasonable access and facilities required for inspection, to the MEW's Inspector. The MEW reserves the right to require additional testing, at any time, to confirm or further investigate a suspected fault. All costs incurred shall be on the MANUFACTURER's account. In no case shall any action of the MEW, or his Inspector, relieve the MANUFACTURER of his responsibility for material, design, quality, or performance of the materials concerned. Inspection and tests performed/witnessed by the MEW's Inspector shall in no way relieve the MANUFACTURER of his obligation to perform the required inspection and tests. Inspection by the MEW's inspector shall be restricted to the following:

- Visual examination and dimensional check of the process connection
- Verification of testing as mentioned under factory testing
- Verification of type of protection certificate or declaration

- Verification of material certificates
- Verification of NACE compliance

The MEW may, at his discretion, appoint a Third Party Inspection Agency to carry out inspection on behalf of, or together with, the MEW's Inspector.

9 TEST CERTIFICATES

The MANUFACTURER shall submit the following certificates in accordance with EN10204 3.1.

a) Hydrostatic test certificates
b) Material test certificate (MIL certificate) for wetted parts.
c) Test report for class of enclosure.
d) Calibration reports for all transmitters.

The VENDOR shall supply a works certificate issued and signed by the MANUFACTURER's inspection, laboratory personnel, or other appropriate responsible employee. The inspection or other employee signing the certificate must be independent of the MANUFACTURER's production department.

The works certificate shall contain numerical results of chemical, electrical and mechanical tests. The type and extent tests shall be as described by the specification for the particular material involved.

In addition, the certificate shall include all information regarding customer, number of order, works number, type and quantity of materials. The production, process heat treatment, and other relevant features, if not limited or prescribed by the material specification should also be included

The test certificate shall confirm that satisfactory testing has been carried out. Manufacture's serial number shall be quoted on all certificates. The certificates shall indicate the method of marking and the material shall be marked in such a manner that it can be traced back to the certificate and test relevant to it.

All non-destructive testing shall be fully certified.

10 SPARE PARTS

The MANUFACTURER shall provide the recommend spare parts on the following basis:

- Commissioning spares
- Two (2) years operation spares

The commissioning and operations spares to be handed over to MEW store.

Parts data shall be listed on proper form and be supplemented with appropriate drawings / bulletins identifying all parts in their respective position".

MANUFACTURER shall provide the Standard Recommended Spare Parts list (for maintenance) form for Spare Parts and Maintenance Data.

The price for the spare parts shall be included in the respective item of the pressure transmitter BOQ.

11 PREPARATION FOR SHIPMENT

VENDOR shall be responsible for the design, supply, assembly and application of all preservation & packaging required for safe transportation, handling and storage of Level Transmitter supplied under this order.

All openings shall be sealed and threaded connections shall be protected with moulded plastic screwed plugs or caps. The Transmitters shall be packed in cartons or crates, suitable for sea shipment in such a way that corrosion and damage to parts and paint is avoided.

Each individual carton or box shall be marked with the Project Name & Code, Purchase Order No., Tag No. and MEW's Name and Address, on the top and side of the carton / crate.

Initial spares shall be packed separately from the main equipment. The box or case shall be clearly marked 'Initial Spares', Project Name & Code, Purchase Order No. and Tag No. on the top and side of the carton. Furthermore each spare part shall have its part number clearly identified and attached.

VENDOR shall be entirely responsible for any claim arising, which is attributable to defective and / or insufficient packing.

Government of State of Kuwait
Ministry of Electricity and Water

Section:- 4C.7

Technical Specification for Pressure / Differential Pressure Gauges

Contents Summary

1 INTRODUCTION

This Specification defines the minimum requirements for the design, manufacture, supply, install, hook up, cabling and testing of Pressure / Differential Pressure Gauges to be used for Pipe line Pressure measurement.

2 REFERENCEDOCUMENTS

2.1 Reference has been made, in this specification, to the latest edition of the following Codes, Standards, and Specifications:

2.1.1 CodesandStandards

BP RP 30-1	-	Instrumentation & Control – Design and Practice
BP RP 30-2	-	Instrumentation & Control – Selection and Use of Measurement Instrumentation
BP RP 32-1	-	Inspection and Testing of New Equipment in Manufacture
BS EN 837-1	-	Specification for Bourdon Tube Pressure and Vacuum Gauges
BS EN 10204	-	Metallic Products – Types of Inspection Documents
BS EN ISO 1461	-	Hot dip galvanized coatings on fabricated Iron and Steel articles - Specification and Test Methods.
IEC 60529	-	Degrees of Protection provided by Enclosures (IP Code) ISO
9000	-	Quality Management and Quality Assurance Standards.
NACE MR0175	-	Standard Material Requirements Sulfide Stress Cracking Resistant Metallic Materials for Oilfield Equipment.

2.1.2 PROJECT SPECIFICATION & DRAWINGS

P&I'D and Piping drawings.

2.2 ORDER OF PRECEDENCE

In case of conflict between the requirements of this specification and the referenced codes, standards, and specifications, the following precedence shall apply:

1. This Specification.
2. Project Particular Specifications.
3. Other International Codes and Standards.

3 DEFINITIONS

To match the definitions, as used in this Specification, the shall follow terminology

4 ENVIRONMENTAL CONDITIONS

The environmental of Kuwait, is severe on all equipment and must be considered carefully before design and procurement of plant and equipment. It must be assumed that, unless of otherwise specified, equipment may be subjected to sand and fine particle dust storms, sand laden winds, chemical contaminants, thunderstorms, heavy rain and extreme temperatures.

4.1 TEMPERATURE AND HUMMIDITY

Summer maximum dry bulb temperature : Summer minimum wet bulb temperature: 65°C, shade

Summer maximum average dry bulb temperature : 28°C

Summer maximum dry bulb temperature (Solar): 50°C

Soil temperature at 1.22m depth: maximum 35°C. minimum 17°C. 80°C
A design of 40°C shall be used for cable system design calculations.

For electrical equipment design, ambient temperature shall be –3°C to 65°C for all indoor and outdoor equipment to be 85°C

Except for as limited by coating on pipes, the surface design temperature (applicable) shall be 93°C for equipment and installation.

a	Direct Sunlight	Exposed metal black body maximum due to solar radiation : 85°C
b	Shade	55°C maximum 45°C average (1day)
		–3°C minimum @ 100% RH

Note : All equipment and materials shall be suitable for this direct sunlight temperature unless installed in a protected environment. Sunshades shall be provided where appropriate.

c) Exposed white body maximum temperature : 63°C

d) Winter minimum dry bulb temperature : –3°C

e) Winter minimum average dry bulb temperature : 7°C

f) Winter minimum average wet bulb temperature : 3°C

Note : These dry and wet bulb temperatures shall be used for winter heating design purposes.

g) Relative humidity maximum at : 55°C, 50% at 0°C, 100% varying from 6 to100%

4.2 Atmospheric Conditions

The atmosphere is generally dusty and corrosive and in some areas may contain traces of hydrogen sulphide.

4.3 Sandstorms

Kuwait is subject to sandstorms, particularly during the summer months:

a) Ambient air range minus –3°C to 55°C

b) 16 grams dust per 100 cubic foot air.

c)

Dust Particle Size (micron)	Wt% Fine Dust (Plus/minus 3%)
0-5	39
5-10	18
10-20	16
20-40	18
40-80	9

4.4 WindData

a) Maximum recorded wind speed : 38 m/s

b) Design maximum wind speed : 45 m/s

c) Summary prevailing wind direction / speed : SE, 6 m/s (Burgan area)

d) Winter prevailing wind direction / speed : NW, 6 m/s (Burgan area)

e) Prevailing wind direction / speed : NNW, 6 m/s (North Kuwait)

f) Summer prevailing wind direction : NNW (North Kuwait)

g) Winter prevailing wind direction : SSE (North Kuwait)

4.5 Rainfall

Kuwait is subject to thunderstorms and heavy rainfall.

a) Annual maximum : 200 mm.

b) 115 mm/h, falling uniformly for 30 minutes

4.6 SeismicData

Kuwait is not subject to earthquakes, and is therefore not an active seismic zone.

5 QUALITY ASSURANCE

5.1 The MANUFACTURER shall operate a Quality System meeting the requirements of the relevant Part of ISO 9000.

5.2 The MANUFACTURER shall ensure that his sub-SUPPLIERs operate a quality system meeting the specified conformance criteria to ISO 9000. The MANUFACTURER's quality system shall be subject to the MEW's approval prior to commitment to a Purchase Order.

Major sub-SUPPLIERs shall be subject to identical approvals. The MEW reserves the right to conduct a Quality Audit at the MANUFACTURER's/sub-SUPPLIER's facilities at any stage during manufacture.

6 DESIGN AND FABRICATION

6.1 General

The Pressure / Differential Pressure Gauge Gauges shall be of the diaphragm chemical seal type as described in the related Data Sheets and shall be suitable for continuous operation in desert conditions under ambient temperature and humidity. They shall meet the environmental conditions outlined under the above Section 4.1.

6.2 Design and Construction

6.2.1 Pressure Element,Gauge Movement and Socket

The pressure-sensing element shall be Bourdon tube type unless specified otherwise in the related Data Sheets. The Bourdon tube shall be placed at least 7 mm inside the shank.

Bourdon elements shall be directly connected to the socket without any capillary in-between through two way manifold for PG and five way manifold for DPG.

Primary elements shall withstand the over-pressure specified in the related Data Sheets for at least 30 minutes without having their elastic characteristics affected.

The gauge movement shall be adjustable for calibration purpose and the use of 'S' link for calibration of span is not permitted.

The fittings between shank and tube shall be tight, of a sliding nature. The fillet weld shall at least have a leg-length equal to the wall thickness of the tube. The fillet-weld shall be smooth.

The pressure gauge shall be supplied complete with diaphragm chemical seal, with manifold for flushing connection, to suit flange process connection in accordance with related data sheets.

The differential pressure gauge shall be supplied complete with chemcial diaphragm seals, flushing point, and plug screws, to suit process connections in accordance with related data sheets.

The differential pressure gauge shall be supplied with mounting bracket and adapter for 2" pipe and shall be suitable to mount on 2" pipe support as per ISA std hookup drawing.

6.2.2 CASES AND DIAL

Pressure / Differential Pressure Gauges shall have an Stainless steel 6-inch (150/160 mm) circular dial.

Pressure / Differential Pressure Gauges shall be of safety pattern construction and shall be provided with blow out back plates and shatterproof lens.

All Pressure / Differential Pressure Gauges shall have dual scales calibrated in 'Psig/Psi' and 'barg/Bar', with black lettering on white background.

6.2.3 Over-range

The gauges shall have over-range protection up to the maximum rating as stated in the related Data Sheets without temporary or permanent damage. The gauge shall

be able to withstand, without affect on the zero or calibration range, the safety relief pressure of the system in which it is installed.

6.2.4 PROCESS CONNECTION

The process connection for Pressure / Differential Pressure Gauges shall be ¾'' NPT (F) or 2'' flanged connection (chemical plant) per piping design, unless otherwise specified. The Pressure Rating to be PN16. The price for the 2'' flanged and ¾'' process isolation valves to be included in the PG item price.

Pressure / Differential Pressure Gauges shall have 1/2" NPT (M) and piping process connection tapping shall be ¾'' NPT (F). unless otherwise specified.

6.2.5 Range

Pressure / Differential Pressure Gauges ranges shall be selected in such a way that normal working pressure shall be in the middle third of the span.

For large turndown requirements, the normal pressure can be read at a maximum of 75% of scale provided that the maximum pressure is not above 90% of scale. Range

shall be selected from the BS EN 837-1 standard list

6.3 Welding

Where welding is carried out the welding procedure and the welder or welding operator shall be qualified under the provisions of ANSI B31.3. All welds subject to line pressure shall comply with the requirements of Section IX of the ASME Boiler and Pressure Vessel Code.

6.4 Hookmaterials:-

The hook-up and impulse tubing for the Pressure Gauge and Differential Pressure Gauge material shall be SS316L including tubes, fittings, valves, union, tee, elbow, reducer, coupling etc…

The hook –up material for the Brackish water service to be monel and compliance with NACE MR 0175.

6.5 Manifold:-

Two manifold (SS316L) to be provided for the Pressure gauge and five way manifold for the Differential Pressure Gauge.

The manifold to be provided from the manufacturer and install as integral part of the instruments.

The manifold material for the Brackish water service to be monel and compliance with NACE MR 0175.

6.6 Datasheets:-

The Pressure / Differential Pressure Gauge Gauges shall be diaphragm type chemical seal and shall be suitable for continuous operation in desert conditions under ambient temperature and humidity. They shall meet in Kuwait environmental conditions.

Data sheet for Pressure Gauge.

Material ,Element ,Case ram Diaph ,Socket movement ,seal housing	Accuracy	Over Range Protection	Meausrment Device	Enclosure Cert./IP	Certificate
SS316 L Wetted Parts for Brackish Water material to be Monel 400.	+/- 0.5% AND Zero /span adjustable	130% FSD AND zero point stopper	Scale:- Dual, Dial: 100mm, Lens: Shatter Proof Glass, Movement damping: Liquid filled (suitable for chlorine service)	Zone-2, Gr. IIB,T3 & IP68	Calibration , Material test and IP68, certificates

a) Instrument data sheets to be prepared as per ISA–20–1981 STANDARD and submitted to MEW approval, before procurement of materials.

b) The Pressure Gauge supplied for the Brackish Water Service to be Monel.

c) The Pressure Gauge supplied to be SS316L and as per manufacturer recommendations.

d) All Wetted parts shall meet the requirements of NACE MR0175 / ISO 15156.

e) Ambient Temperature : Min 3°C at100%RH, Max. 52°C(Shade) at 50%RH, Max. Radiation Black Body 85°C, White body 63°C. f) Ingress Protection IP 68 (minimum).

g) Zero and Over range stop required.

h) Dial marking shall be black upon a non - glaring white finish.

j) Blow-out Protection is required on the back side.

k) SS 316 two valve manifold shall be supplied along with the pressure gauge.

l) Calibration Cert. , Material Test Cert., Certificate of Conformity , NACE Compliance Certificates to be provided alongwith material.

m) Separate hanging SS316 tag plate of 60mm X 25mm X 1.5mm deep engraved with ink filling in Arial font shall be provided.

n) Range shall be varied as per the successful vendor manufacturing standards. o) Sensor

temperature limit shall be equal to design temperature.

6.7 Tagging

Pressure / Differential Pressure Gauges shall be provided with an identification plate, with all data clearly stamped on a corrosion resistant plate permanently attached to each instrument by means of rivets or pins and shall indicate, as a minimum, the following:

- Name of the MANUFACTURER or Trade Mark
- MANUFACTURER's Model Number.
- Instrument Tag Number
- Serial Number
- Year of Manufacture
- Range including units of measure

6.8 Painting

Where applicable, painting shall as per MANUFACTURER own standard, with MEWs approval. Stainless steel Pressure / Differential Pressure Gauges shall not be painted.

7 DOCUMENTATION

7.1 Documentation Required with Tender Technical Bid

- Full technical literature for the equipment offered.
- An unqualified statement of compliance with the specification and data sheet requirements.
- A list of all accessory items together with MANUFACTURER's name and part number.
- The VENDOR shall provide a completed copy of the instrumentation data sheets with all changes entered.

7.2 DocumentRequiredforApproval

- General Arrangement / Construction Drawings
- Overall dimensions of equipment
- Quality Control Manual and Quality Plan

On receipt of written approval, the MANUFACTURER shall submit to the MEW all approved documents as listed above.

Prior to shipment, the MANUFACTURER shall submit the test certificates as listed in Section 9 of this specification.

Documents shall be in the English Language.

8 INSPECTIONANDTESTS

8.1 General

The MANUFACTURER shall meet the inspection and testing requirements of BP RP 32-1. All required inspection and testing works shall be carried out at MANUFACTURER's work prior to shipment

8.2 FactoryTesting

Each gauge shall be hydrostatically pressure tested at minimum 1.25 times the chamber rating.

For verification of NACE MR 01-75 compliance, the gauges shall be subjected to a NACE hardness test (or test sample of raw parts).

Functional / Calibration Test shall be conducted on each Pressure / Differential Pressure Gauges.

The MEW also reserves the right to witness tests as indicated above, at the MANUFACTURER's works, prior to shipment. The MANUFACTURER shall give reasonable notice of date and time for such inspection and shall provide reasonable access and facilities required for inspection, to the MEW's Inspector. The MEW reserves the right to require additional testing, at any time, to confirm or further investigate a suspected fault. All costs incurred shall be on the MANUFACTURER's account. In no case shall any action of the MEW, or his Inspector, relieve the MANUFACTURER of his responsibility for material, design, quality, or performance of the materials concerned. Inspection and tests performed/witnessed by the MEW's Inspector shall in no way relieve the MANUFACTURER of his obligation to perform the required inspection and tests. Inspection by the MEW's inspector shall be restricted to the following:

- Visual examination and dimensional check of the process connection
- Verification of testing as mentioned under factory testing
- Verification of material certificates

The MEW may, at his discretion, appoint a Third Party Inspection Agency to carry out inspection on behalf of, or together with, the MEW's Inspector.

9 TEST CERTIFICATES

The MANUFACTURER shall submit the following certificates in accordance with EN10204 3.1.

a) Material test certificate (MIL certificate) for wetted parts including gauge socket, bourdon tube, glass, etc.
b) Test report for class of enclosure.
c) Calibration reports for all gauges.

The VENDOR shall supply a works certificate issued and signed by the MANUFACTURER's inspection, laboratory personnel, or other appropriate responsible employee. The inspection or other employee signing the certificate must be independent of the MANUFACTURER's production department.

The works certificate shall contain numerical results of chemical, electrical and mechanical tests. The type and extent tests shall be as described by the specification for the particular material involved.

In addition, the certificate shall include all information regarding customer, number of order, works number, type and quantity of materials. The production, process heat treatment, and other relevant features, if not limited or prescribed by the material specification should also be included

The test certificate shall confirm that satisfactory testing has been carried out. Manufacture's serial number shall be quoted on all certificates. The certificates shall indicate the method of marking and the material shall be marked in such a manner that it can be traced back to the certificate and test relevant to it.

All non-destructive testing shall be fully certified.

10 SPAREPARTS

The MANUFACTURER shall provide the recommend spare parts on the following basis:

- Commissioning spares
- Two (2) years operation spares

The commissioning and operations spares to be handed over to MEW store.

Parts data shall be listed on proper form and be supplemented with appropriate drawings / bulletins identifying all parts in their respective position".

MANUFACTURER shall provide the Standard Recommended Spare Parts list (for maintenance) form as per Attachment for Spare Parts and Maintenance Data.

The price for the spare parts shall be included in the respective item of the pressure gauge BOQ.

11 PREPARATIONFORSHIPMENT

VENDOR shall be responsible for the design, supply, assembly and application of all preservation & packaging required for safe transportation, handling and storage of Pressure / Differential Pressure Gauges supplied under this order.

All openings shall be sealed and threaded connections shall be protected with moulded plastic screwed plugs or caps. The Pressure / Differential Pressure Gauges shall be packed in cartons or crates, suitable for sea shipment in such a way that corrosion and damage to parts and paint is avoided.

Each individual carton or box shall be marked with the Project Name & Code, Purchase Order No., Tag No. and MEW's Name and Address, on the top and side of the carton / crate.

Initial spares shall be packed separately from the main equipment. The box or case shall be clearly marked 'Initial Spares', Project Name & Code, Purchase Order No. and Tag No. on the top and side of the carton. Furthermore each spare part shall have its part number clearly identified and attached.

VENDOR shall be entirely responsible for any claim arising, which is attributable to defective and / or insufficient packing.

Government of State of Kuwait
Ministry of Electricity and Water

Section:- 4C.8

Technical Specification for Pressure Switches.

Contents Summary

1 INTRODUCTION

This Specification defines the minimum requirements for the design, manufacture, supply, install, hook up, cabling and testing of Pressure switches (PSLL, PSHH) to be used for pipeline pressure alarm loops and interlocks to equipments.

2 REFERENCE DOCUMENTS

2.1 Reference has been made, in this specification, to the latest edition of the following Codes, Standards, and Specifications:

2.1.1 Codes and Standards

BP RP 30-1 - Instrumentation & Control – Design and Practice

BP RP 30-2 - Instrumentation & Control – Selection and Use of Measurement Instrumentation

BP RP 32-1 - Inspection and Testing of New Equipment in Manufacture

BS EN 5345 - Code of Practice for Selection, Installation and Maintenance of Electrical Apparatus for Use in Potentially Explosive Atmospheres

BS EN 10204 - Metallic Products – Types of Inspection Documents

BS EN ISO 1461 Hot dip galvanized coatings on fabricated Iron and Steel articles - Specification and Test Methods.

BASEEFA - British Approvals Services for Electrical Equipment in Flammable Atmosphere

IEC 60529 - Degrees of Protection provided by Enclosures (IP Code)

IEC 60770 - Switches for Use in Industrial Process Control System

ISO 9000 - Quality Management and Quality Assurance Standards.

NACE MR0175 - Standard Material Requirements Sulfide Stress Cracking Resistant Metallic Materials for Oilfield Equipment.

2.1.2 Project Specifications and Drawings.

2.2 Order of Precedence

In case of conflict between the requirements of this specification and the referenced codes, standards, and specifications, the following precedence shall apply:

1. This Specification.
2. Project Particular Specifications.
3. Other International Codes and Standards.

3 DEFINITIONS

To match the definitions, as used in this Specification, the following terminology shall be used:

4 ENVIRONMENTAL CONDITIONS

The environmental of Kuwait, is severe on all equipment and must be considered carefully before design and procurement of plant and equipment. It must be assumed that, unless otherwise specified, equipment may be subjected to sand and fine particle dust storms, sand laden winds, chemical contaminants, thunderstorms, heavy rain and extreme temperatures.

4.1 Temperature and Humidity

Summer maximum dry bulb temperature :	65°C, shade
Summer minimum wet bulb temperature :	28°C Summer
maximum average dry bulb temperature :	50°C Summer
maximum dry bulb temperature (Solar):	80°C

Soil temperature at 1.22m depth: maximum 35°C. minimum 17°C. A design of 40°C shall be used for cable system design calculations.

For electrical equipment design, ambient temperature shall be –3°C to 50°C for all indoor (inside a/c room) and outdoor equipment shall be –3°C to 85°C for the pressure switches with all accessories.

Except for as limited by coating on pipes, the surface design temperature (applicable) shall be 93°C for equipment and installation.

a) Direct Sunlight : Exposed metal black body maximum temperature due to solar radiation : 85°C

b) Shade Temperature : 55°C maximum
45°C average (1day)
–3°C minimum @ 100% RH

Note : All equipment and materials shall be suitable for this direct sunlight temperature unless installed in a protected environment. Sunshades shall be provided where appropriate.

c) Exposed white body maximum temperature : 63°C

d) Winter minimum dry bulb temperature : –3°C

e) Winter minimum average dry bulb temperature : 7°C

f) Winter minimum average wet bulb temperature : 3°C

Note : These dry and wet bulb temperatures shall be used for winter heating design purposes.

g) Relative humidity maximum at : 55°C, 50% at 0°C, 100% varying from 6 to 100%

4.2 Atmospheric Conditions

The atmosphere is generally dusty and corrosive and in some areas may contain traces of hydrogen sulphide.

4.3 Sandstorms

Kuwait is subject to sandstorms, particularly during the summer months:

a) Ambient air range minus –3°C to 55°C

b) 16 grams dust per 100 cubic foot air.

c)

DustParticleSize (micron)	Wt%FineDust (Plus/minus 3%)
0-5	39
5-10	18
10-20	16
20-40	18
40-80	9

4.4 Wind Data

a) Maximum recorded wind speed : 38 m/s

b) Design maximum wind speed : 45 m/s

c) Summary prevailing wind direction / speed : SE, 6 m/s (Burgan area)

d) Winter prevailing wind direction / speed : NW, 6 m/s (Burgan area)

e) Prevailing wind direction / speed : NNW, 6 m/s (North Kuwait)

f) Summer prevailing wind direction : NNW (North Kuwait)

g) Winter prevailing wind direction : SSE (North Kuwait)

4.5 Rainfall

Kuwait is subject to thunderstorms and heavy rainfall.

a) Annual maximum : 200mm.

b) 115 mm/h, falling uniformly for 30 minutes

4.6 Seismic Data

Kuwait is not subject to earthquakes, and is therefore not an active seismic zone.

5 QUALITY ASSURANCE

The MANUFACTURER shall operate a Quality System meeting the requirements of the relevant Part of ISO 9000.

The MANUFACTURER shall ensure that his sub-SUPPLIERs operate a quality system meeting the specified conformance criteria to ISO 9000. The MANUFACTURER's quality system shall be subject to the MEW's approval prior to commitment to a Purchase Order.

Major Sub-SUPPLIERs shall be subject to identical approvals. The MEW reserves the right to conduct a Quality Audit at the MANUFACTURER's/Sub-SUPPLIER's facilities at any stage during manufacture.

6 DESIGN AND CONSTRUCTION

6.1 General

The pressure and differential pressure switch shall be latest 'state-of the-art' technology, proven reliable type, five years stability and can withstand ambient / static head / surge conditions. All accessories shall be included including two way way manifold, tubing, fitting, etc..

The switches design shall guarantee long lifetime and long re-calibration intervals, have very high reliability with ease of maintenance and shall comply with the industrial standards normally followed.

6.2 Sensor

The Sensor shall be Diaphram or Bellows type and meet the specification requirements:-

Element Type	Diaphragm or Bellows Type as per requirement
Element Material	SS-316 (with NACE) for F.W water service and Monel 400 for BW service.
Span Limit	By Vendor
Process Connection	3/4" NPT

Signal output	Accuracy	Over range Protection	Material	Enclosure Cert./IP	Certificate
Pot free contact. rating 110v AC, 5A, DPDT Switch. Hermetically sealed.	+/-0.5% Dead band adjustable	130% FSD	***Enclosure Housing***:- SS316L ***Sensor Diaphram***:- SS316L for F.W and Monel 400 for B.W Wetted parts comply to NACE ***Two way manifold***:- SS316L for F.W and Monel for B.W ***Mounting Bracket & Accessories:-*** SS316L ***Install inside GRP instrument housing box Size.***	Zone-2, Gr. IIB,T3 & IP68	Calibration, Material test and IP68, certificates

6.3 Body:-

The Switches shall not have any drain connections in the body. They shall also have over range protection without temporary or permanent damage.

6.4 Switches:-

The Switches shall comply the following specification:-

Wherever specified in the related Data Sheets, the Pressure Switches for towers, high surges, Pipe lines, and diesel tanks shall be provided with 1x DPDT Switch rated and contact rating shall be 110v AC, 5A, Pot. free contact for high or low alarms, as per project spec. requirements.

6.5 Performance

The Switches accuracy, including the combined effect of linearity, hysterisis and repeatability shall be equal to or better than 0.5%. With reference to IEC 60770, errors shall be expressed as percentage of calibrated span, unless stated otherwise.

6.6 Switches Housing

The Switches electronics shall be field-mounted type. The Switches enclosure shall be SS316L and shall be weather proof to IP 68 (below ground), IP65 (above ground installations) as a minimum.

6.7 Wetted Parts

All wetted parts, the remote diaphragm seal shall meet the requirements of NACE MR 01-75 and shall be as specified in the related Data Sheet for Pressure and Differential Pressure Switches.

6.8 Cable Entry / Connection

The electrical signal cable entry shall be M20 x 1.5 ISO threaded or manufacturer std. Unused cable entries shall be plugged (SS316L-Plug) off in compliance with the specified electrical safety.

Signal wiring terminals shall be of the screw type or manufacture std. All terminals for electrical connections shall be clearly numbered. The terminals polarity, where applicable, shall be permanently marked.

NOTE: Switches with flying leads are not acceptable.

6.9 Hook materials:-

The hook-up and impulse tubing for the Pressure switch material shall be SS316L (for F.W) and Monel 400 for B.W including tubes, fittings, valves, union, tee, elbow, reducer, coupling etc…

The hook –up material for the Brackish water service to be monel and compliance with NACE MR 0175.

6.10 Manifold:-

Two way manifold (SS316L) to be provided for the Pressure Switches from the manufacturer.

The manifold material for the Brackish water service to be monel and compliance with NACE MR 0175.

6.11 Tagging

Switches shall be provided with an identification plate, with all data clearly stamped on a corrosion resistant plate permanently attached to each instrument by means of rivets or pins and shall indicate, as a minimum, the following:

- Name of the MANUFACTURER or Trade Mark
- Manufacturer's Model Number
- Instrument Tag Number
- Serial Number
- Year of Manufacture
- Range & Calibration (including units of measurement)
- Body Rating (including units)

- Electrical safety (type of protection)
- Output signal

Note 1: Each Switches shall be provided with a Certification Plate fixed with a stainless steel wire to the Switches.

The Separate hanging SS316 tag plate of 60mm X 25mm X 1.5mm deep engraved with ink filling in Arial font shall be provided.

The Certification Plate shall carry necessary details with regard to statutory approval as follows:

i) Type of approval and mark of certifying body.
ii) Certifying authority name.
iii) License / certificate number and date
iv) Area Classification Group and Temperature Rating

6.12 Mounting Arrangements

The Switches shall be suitable to mount on 2" pipe support (stanchion) as per the ISA std. instrument hook-up drawing.

6.13 Accessories

The process connection shall be ¾'' and flange in accordance with the related Data Sheets for Pressure and Differential Pressure Switches.

The Switches shall be supplied with mounting brackets, bolt, nuts, clamps, etc. as specified in the related Data Sheets for Pressure and Differential Pressure Switches.

All the mounting accessories materials to be SS316L.

6.14 Painting

Where applicable, painting shall as per MANUFACTURER own standard, with MEW's approval. Stainless steel Pressure Switches shall not be painted.

7 DOCUMENTATION

7.1 Documentation Required for approval

- Full technical literature for the equipment offered.
- An unqualified statement of compliance with the specification and data sheet requirements.

- A list of all accessory items together with MANUFACTURER's name and part number.
- The VENDOR shall provide a completed copy of the instrumentation data sheets with all changes entered.
- ISA instrument data sheet filled by vendor
- General Arrangement / Construction Drawings
- Overall dimensions of equipment
- Design Calculations
- Material and electrical certificates
- Quality Control Manual and Quality Plan

On receipt of written approval, the MANUFACTURER shall submit to the MEW all approved documents as listed above.

Prior to shipment, the MANUFACTURER shall submit the test certificates as listed in Section 9 of this Specification.

Documents shall be in the English Language.

8 INSPECTION AND TESTS

8.1 General

The MANUFACTURER shall meet the inspection and testing requirements of BP RP 32-1. All required inspection and testing works shall be carried out at MANUFACTURER's work prior to shipment

8.2 Factory Testing

Each Switches shall be hydrostatically pressure tested at minimum 1.25 times the chamber rating.

For verification of NACE MR 01-75 compliance, the Switches shall be subjected to a NACE hardness (or test sample of raw parts) on chamber parts and blind (oral) flanges but not diaphragms.

Functional / Calibration Test shall be conducted on each Pressure and Differential Pressure Switches.

The MEW also reserves the right to witness tests as indicated above, at the MANUFACTURER's works, prior to shipment. The MANUFACTURER shall give reasonable notice of date and time for such inspection and shall provide reasonable access and facilities required for inspection, to the MEW's Inspector.

The MEW reserves the right to require additional testing, at any time, to confirm or further investigate a suspected fault. All costs incurred shall be on the MANUFACTURER's account. In no case shall any action of the MEW, or his Inspector, relieve the MANUFACTURER of his responsibility for material, design, quality, or performance of the materials concerned. Inspection and tests performed/witnessed by the MEW's Inspector shall in no way relieve the MANUFACTURER of his obligation to perform the required inspection and tests. Inspection by the MEW's inspector shall be restricted to the following:

- Visual examination and dimensional check of the process connection
- Verification of testing as mentioned under factory testing
- Verification of type of protection certificate or declaration
- Verification of material certificates
- Verification of NACE compliance

The MEW may, at his discretion, appoint a Third Party Inspection Agency to carry out inspection on behalf of, or together with, the MEW's Inspector.

9 TEST CERTIFICATES

The MANUFACTURER shall submit the following certificates in accordance with EN10204 3.1

a) Hydrostatic test certificates
b) Material test certificate (MIL certificate) for wetted parts.
c) Test report for class of enclosure.
d) Calibration reports for all Switches.

The VENDOR shall supply a works certificate issued and signed by the MANUFACTURER's inspection, laboratory personnel, or other appropriate responsible employee. The inspection or other employee signing the certificate must be independent of the MANUFACTURER's production department.

The works certificate shall contain numerical results of chemical, electrical and mechanical tests. The type and extent tests shall be as described by the specification for the particular material involved.

In addition, the certificate shall include all information regarding customer, number of order, works number, type and quantity of materials. The production, process heat treatment, and other relevant features, if not limited or prescribed by the material specification should also be included

The test certificate shall confirm that satisfactory testing has been carried out. Manufacture's serial number shall be quoted on all certificates. The certificates shall indicate the method of marking and the material shall be marked in such a manner that it can be traced back to the certificate and test relevant to it.

All non-destructive testing shall be fully certified.

10 SPARE PARTS

The MANUFACTURER shall provide the recommend spare parts on the following basis:

- Commissioning spares
- Two (2) years operation spares

The commissioning and operations spares to be handed over to MEW store.

Parts data shall be listed on proper form and be supplemented with appropriate drawings / bulletins identifying all parts in their respective position".

MANUFACTURER shall provide the Standard Recommended Spare Parts list (for maintenance) form for Spare Parts and Maintenance Data.

The price for the spare parts shall be included in the respective item of the pressure transmitter BOQ.

11 PREPARATION FOR SHIPMENT

VENDOR shall be responsible for the design, supply, assembly and application of all preservation & packaging required for safe transportation, handling and storage of Pressure & Differential Pressure Switches supplied under this order.

All openings shall be sealed and threaded connections shall be protected with moulded plastic screwed plugs or caps. The Switches shall be packed in cartons or crates, suitable for sea shipment in such a way that corrosion and damage to parts and paint is avoided.

Each individual carton or box shall be marked with the Project Name & Code, Purchase Order No., Tag No. and MEW's Name and Address, on the top and side of the carton / crate.

Initial spares shall be packed separately from the main equipment. The box or case shall be clearly marked 'Initial Spares', Project Name & Code, Purchase Order No.

and Tag No. on the top and side of the carton. Furthermore each spare part shall have its part number clearly identified and attached.

VENDOR shall be entirely responsible for any claim arising, which is attributable to defective and / or insufficient packing.

Government of State of Kuwait
Ministry of Electricity and Water

SECTION 4C.9

Technical Specification for Level Transmitter (Using Differential Pressure measurement method)

Contents Summary

1 INTRODUCTION

This Specification defines the minimum requirements for the design, manufacture, supply, install, cabling, hook-up, testing and commissioning of **level transmitter (differential pressure measurement method)** used for the water tower level measurement for the Project.

2 REFERENCE DOCUMENTS

2.1 Reference has been made, in this specification, to the latest edition of the following Codes, Standards, and Specifications:

2.1.1 Codes and Standards

BP RP 30-1	- Instrumentation & Control – Design and Practice
BP RP 30-2	- Instrumentation & Control – Selection and Use of Measurement Instrumentation
BP RP 32-1	- Inspection and Testing of New Equipment in Manufacture
BS EN 5345	- Code of Practice for Selection, Installation and Maintenance of Electrical Apparatus for Use in Potentially Explosive Atmospheres
BS EN 10204	- Metallic Products – Types of Inspection Documents
BS EN ISO 1461	Hot dip galvanized coatings on fabricated Iron and Steel articles - Specification and Test Methods.
BASEEFA	- British Approvals Services for Electrical Equipment in Flammable Atmosphere
IEC 60529	- Degrees of Protection provided by Enclosures (IP Code)
IEC 60770	- Transmitters for Use in Industrial Process Control System
ISO 9000	- Quality Management and Quality Assurance Standards.
NACE MR0175	- Standard Material Requirements Sulfide Stress Cracking Resistant Metallic Materials for Oilfield Equipment.

2.1.2 Project Specifications and Drawings.

2.2 Order of Precedence

In case of conflict between the requirements of this specification and the referenced codes, standards, and specifications, the following precedence shall apply:

1. This Specification.
2. Project Particular Specifications.
3. Other International Codes and Standards.

3 DEFINITIONS

To match the definitions, as specified in the spec.

4 ENVIRONMENTAL CONDITIONS

The environmental of Kuwait, is severe on all equipment and must be considered carefully before design and procurement of plant and equipment. It must be assumed that, unless otherwise specified, equipment may be subjected to sand and fine particle dust storms, sand laden winds, chemical contaminants, thunderstorms, heavy rain and extreme temperatures.

4.1 Temperature and Humidity

Summer maximum dry bulb temperature : 65°C,

shade Summer minimum wet bulb temperature : 28°C

Summer maximum average dry bulb temperature : 50°C

Summer maximum dry bulb temperature (Solar): 80°C

Soil temperature at 1.22m depth: maximum 35°C. minimum 17°C.
A design of 40°C shall be used for cable system design calculations.

For electrical equipment design, ambient temperature shall be –3°C to 50°C for all indoor (inside a/c room) and outdoor equipment shall be –3°C to 85°C for the level transmitter with all accessories.

Except for as limited by coating on pipes, the surface design temperature (applicable) shall be 93°C for equipment and installation.

a) Direct Sunlight : Exposed metal black body maximum temperature due to solar radiation : 85°C

b) Shade Temperature : 55°C maximum
45°C average (1day)
–3°C minimum @ 100% RH

Note: All equipment and materials shall be suitable for this direct sunlight temperature unless installed in a protected environment. Sunshades shall be provided where appropriate.

c) Exposed white body maximum temperature : 65°C

d) Winter minimum dry bulb temperature : –3°C

e) Winter minimum average dry bulb temperature : 7°C

f) Winter minimum average wet bulb temperature : 3°C

Note : These dry and wet bulb temperatures shall be used for winter heating design purposes.

g) Relative humidity maximum at : 55°C, 50% at 0°C, 100% varying from 6 to 100%

4.2 Atmospheric Conditions

The atmosphere is generally dusty and corrosive and in some areas may contain traces of hydrogen sulphide.

4.3 Sandstorms

Kuwait is subject to sandstorms, particularly during the summer months:

a) Ambient air range minus –3°C to 55°C

b) 16 grams dust per 100 cubic foot air. c)

Dust Particle Size (micron)	Wt% Fine Dust (Plus/minus 3%)

5-10	18
10-20	16
20-40	18
40-80	9

4.4 Wind Data

a) Maximum recorded windspeed : 38 m/s

b) Design maximum windspeed : 45 m/s

c) Summary prevailing wind direction / speed : SE, 6 m/s (Burgan area)

d) Winter prevailing wind direction / speed : NW, 6 m/s (Burgan area)

e) Prevailing wind direction / speed : NNW, 6 m/s (North Kuwait)

f) Summer prevailing wind direction : NNW (North Kuwait)

g) Winter prevailing wind direction : SSE (North Kuwait)

4.5 Rainfall

Kuwait is subject to thunderstorms and heavy rainfall.

a) Annual maximum : 200mm.

b) 115 mm/h, falling uniformly for 30 minutes

4.6 Seismic Data

Kuwait is not subject to earthquakes, and is therefore not an active seismic zone.

5 QUALITYASSURANCE

The MANUFACTURER shall operate a Quality System meeting the requirements of the relevant Part of ISO 9000.

The MANUFACTURER shall ensure that his sub-SUPPLIERs operate a quality system meeting the specified conformance criteria to ISO 9000. The MANUFACTURER's quality system shall be subject to the MEW's approval prior to commitment to a Purchase Order.

Major Sub-SUPPLIERs shall be subject to identical approvals. The MEW reserves the right to conduct a Quality Audit at the MANUFACTURER's/Sub-SUPPLIER's facilities at any stage during manufacture.

6 DESIGN AND CONSTRUCTION

6.1 General

The Level and differential pressure transmitters shall be a "Smart" type suitable for both analogue and digital simultaneous transmission using open field bus protocol and have non-volatile configuration data storage. A self-diagnostic facility shall be provided.

The system shall be an open system composed of standards-based technology with field devices over smart with HART protocol, 2 wire system, 4-20mA/ 24vDC.

The field-device shall connect to the Process Control Units via. direct hardwired to the redundant DCS I/O modules via. Signal splitter.

The level transmitter shall be of latest 'state-of the-art' technology using modern digital techniques for measurement, signal processing, configuration and self-diagnosis. Transmitter shall have digital display and advanced automatic programmable calibration features.

The level transmitter shall be of proven reliable type, five years stability and can withstand ambient / static head / surge conditions. All accessories shall be included including five way manifold, integrated digital local indication, power supply unit and local volume LED indicator, etc.

The transmitter's design shall guarantee long lifetime and long re-calibration intervals, have very high reliability with ease of maintenance and shall comply with the industrial standards normally followed.

6.2 Sensor

The Sensor module fill fluid shall be silicon oil and comply the following:-

Element Type	Diaphragm Type
Element Material	SS-316L (with NACE) for F.W water service
Span Limit	By Vendor
Process Connection	1/2" NPT F
Fill Fluid	Silicone Oil

6.3 Body:-

The transmitters shall have SS316L vent or drain connections in the body. They shall also have over range protection up to the maximum chamber rating on either side without temporary or permanent damage.

6.4 Transmitter:-

The transmitter shall comply the following specification:-

Type		SMART type with HART protocol
Signal Output		24v DC/4-20mA
Instrument Range	Psig	Vendor to specify
Calibration Range	Psig	As per the design.
Accuracy		+/- 0.03% of Range Span
Build in Indicator		Required, LCD Display with Engg Units
Power supply		Redundant Isolated 24Vdc power supply unit from PCU panel
Cable Entry		ISO, M20
Electrical Connection		Screw Type Terminal
Enclosure Certification		Weather proof certification
Ingress Protection (IP)		65
Surge protection		Built-in Surge module
Over Range Protection		130% of full scale
Materials		
Wetted parts, body, electronic housing enclosure, drain, vent plug, cable entry, gland – materials		SS316L
Five way manifold material		SS316L

The level and differential pressure transmitter shall be installed inside GRP Instrument housing (800x800x400mm, min). The price for the GRP IHB item shall be included in the respective item of transmitter bill of quantity.

6.5 Output

Transmitter output shall be both 4-20 mA with superimposed digital signal complying with open digital field bus communication HART protocol

Power supply:-

Redundant Isolated 24Vdc Power supply, loop powered.

6.6 Electronics

The transmitter electronics shall be solid-state with appropriate 'smart' circuitry. Printed circuit boards (PCB) shall be of a replaceable modular construction, be hermetically sealed or protected by a corrosion resistant coating (tropicalised). PCB shall be plug-in type and vibration free supported. Signal wiring terminals and electronics shall be housed in separate compartments, so that the electronics remain sealed during electrical connection to the signal cable.

6.7 Calibration / Configuration

It shall be possible to perform on-line and remote set point configuration/calibration of the transmitter via a Hand Held Communicator (HHC) using HART protocol. HHC shall be of easy to use and shall be suitable for use in the area classification as specified for transmitters in the related Data Sheets. The fieldbus output of the transmitter shall not be affected during communication with the HHC.

Online Configurability

The system shall support the making of online configuration changes such as calibration, up loading and down loading the software from the DCS workstations, repairs, extensions and modifications to trunk lines. And configure into maintenance management system and Asset management system.

6.8 Adjustments

The zero and span of the transmitters shall be adjusted through the Hand Held Communicator (HHC). A facility for engineering unit selection shall also be available from the HHC. The zero and span adjustments shall be non interactive and continuously adjustable.

6.9 Indication

Transmitters shall be complete with an integral digital output meter with 4 digits, LCD readout via. Hart protocol. The output meter scale shall cover the entire transmitter range of the transmitter in Engineering Units, as indicated in the related Project Data Sheet for Pressure and Differential Pressure Transmitters. In addition to the above, the digital output meter shall be provided with the facility of displaying the measured value as a percentage of the calibrated span.

6.10 Performance

The transmitter accuracy, including the combined effect of linearity, hysterisis and

repeatability shall be equal to or better than 0.03%. With reference to IEC 60770, errors shall be expressed as percentage of calibrated span, unless stated otherwise.

6.11 Temperature Compensation

The transmitter electronics shall include facilities for the temperature compensation. The sensor characterisation curve shall be stored in EPROM.

6.12 Transmitter Housing

The transmitter electronics shall be field-mounted type. The transmitter enclosure shall be SS316L and shall be weather proof to IP 68 inside valve pit and IP65 for above ground installations. The transmitter shall be installed inside GRP Instrument housing (800x800x400mm, min). The price for the GRP IHB item shall be included in the respective item of transmitter bill of quantity.

No Aluminium in its un-anodised form shall be used. No copper or its alloys shall be used.

The units shall be supplied in housings suitable for environmental condition as specified in the above Section.

6.13 Wetted Parts

All wetted parts, the remote diaphragm seal shall meet the requirements of NACE MR 01-75 and shall be as specified in the related Data Sheet for level Transmitters.

6.14 Cable Entry / Connection

The electrical signal cable entry shall be M20 x 1.5 ISO threaded or manufacturer std. Unused cable entries shall be plugged (SS316L-Plug) off in compliance with the specified electrical safety.

Signal wiring terminals shall be of the screw type or manufacture std. All terminals for electrical connections shall be clearly numbered. The terminals polarity, where applicable, shall be permanently marked.

NOTE: Transmitters with flying leads are not acceptable.

6.15 Hook materials:-

The hook-up and impulse tubing for the level transmitters material shall be SS316L including tubes, fittings, valves, union, tee, elbow, reducer, coupling etc…
The wetted parts on the hook up material shall compliance with NACE MR 0175.

The level transmitter shall be installed inside GRP Instrument Housing Box.

The hookup piping shall be routed from the the Bottom of the tower via. 3'' SS316L Pipe with proper adequate SS316L support angle and clamps with required accessories.

6.16 Manifold:-

Five way manifold (SS316L) to be provided for the level transmitter from the manufacturer as a integral part of the transmitter.

The manifold wetted parts material shall compliance with NACE MR 0175.

6.17 Tagging

Transmitters shall be provided with an identification plate, with all data clearly stamped on a corrosion resistant plate permanently attached to each instrument by means of rivets or pins and shall indicate, as a minimum, the following:

- Name of the MANUFACTURER or Trade Mark
- Manufacturer's Model Number
- Instrument Tag Number
- Serial Number
- Year of Manufacture
- Range & Calibration (including units of measurement)
- Body Rating (including units)
- Electrical safety (type of protection)
- Output signal

Note 1: Each transmitter shall be provided with a Certification Plate fixed with a stainless steel wire to the transmitter.

The Separate hanging SS316 tag plate of 60mm X 25mm X 1.5mm deep engraved with ink filling in Arial font shall be provided.

The Certification Plate shall carry necessary details with regard to statutory approval as follows:

i) Type of approval and mark of certifying body
ii) Certifying authority name.
iii) License / certificate number and date
iv) Area Classification Group and Temperature Rating

6.18 Mounting Arrangements

The transmitter shall be suitable to mount on 2" pipe support (stanchion) as per the ISA std. instrument hook-up drawing.

6.19 Accessories

The process connection shall be ¾'' and flange in accordance with the related Data Sheets for level transmitters

The transmitter shall be supplied with mounting brackets, bolt, nuts, clamps, etc. as specified in the related Data Sheets for level transmitters.

All the mounting accessories materials to be SS316L

6.20 Painting

Where applicable, painting shall as per MANUFACTURER own standard, with MEW's approval. Stainless steel Level Transmitter shall not be painted.

Signal output	Accuracy	Local Display	Over range protection	Housing Enclosure &Sensor materials	Hook up materials & accessories.	Enclosure certification	Certificate
Smart, with Hart protocol 4-20mA, 24vDC	+/- 0.03%	Builtin LCD Engineering unit configurable	200%	SS 316L	SS316L, five way manifold, tubes, fittings and 2'' Pipe mounting with mounting bracket.	Zone.2, Gr.IIB	MTC and Calibration

The manufacturer should submit the data sheet in ISA format for MEW approval.

6.22 General:-

The transmitter shall have the following features,

i. Configuration of transmitters in online operation.

ii. Loading and saving device data (Up load/Down load)

iii. Quick and safe commissioning of the same measuring points by copying the configuration data from one transmitter to another transmitter.

iv. Simple diagnosis by recording diverse events such as alarms, configuration changes, counters for measuring range undershoot and overshoot for pressure as well as user

limit overshoot and undershoot.

v. Easy and safe menu guided operation for quick setup via. local configuration using the HHC and soft pushbuttons.

One no. Hart field HHC (Hand Held Configurator) to be supplied as part of the contract requirement, the price for the HHC to be included in the respective item of the pressure transmitter in the BOQ.

vi. Local Display (Either integral type provided it is easily locally accessed and monitored or remote mounted):-

viii. Comprehensive diagnostic functions (Fault and warning message) and Programmable with an integral programming keypad an integral part of the transmitter.

ix. Signals on alarm:- Last valued output value, last good value, failsafe value, status bad, and wrong value

x. The mean time between failure for transducers shall be not less than 15 years, and the performance of the measurement system shall be as below or better.

7 DOCUMENTATION

7.1 Documentation Required for approval

- Full technical literature for the equipment offered.
- An unqualified statement of compliance with the specification and data sheet requirements.
- A list of all accessory items together with MANUFACTURER's name and part number.
- The VENDOR shall provide a completed copy of the instrumentation data sheets with all changes entered.
- General Arrangement / Construction Drawings
- Overall dimensions of equipment
- Design Calculations
- Material and electrical certificates
- Quality Control Manual and Quality Plan

On receipt of written approval, the MANUFACTURER shall submit to the MEW all approved documents as listed above.

Prior to shipment, the MANUFACTURER shall submit the test certificates as listed in Section 9 of this Specification.

Documents shall be in the English Language.

8 INSPECTION AND TESTS

8.1 General

The MANUFACTURER shall meet the inspection and testing requirements of BP RP 32-1. All required inspection and testing works shall be carried out at MANUFACTURER's work prior to shipment

8.2 Factory Testing

Each transmitter shall be hydrostatically pressure tested at minimum 1.25 times the chamber rating.

For verification of NACE MR 01-75 compliance, the transmitters shall be subjected to a NACE hardness (or test sample of raw parts) on chamber parts and blind (oral) flanges but not diaphragms.

Functional / Calibration Test shall be conducted on each Level Transmitter.

The MEW also reserves the right to witness tests as indicated above, at the MANUFACTURER's works, prior to shipment. The MANUFACTURER shall give reasonable notice of date and time for such inspection and shall provide reasonable access and facilities required for inspection, to the MEW's Inspector. The MEW reserves the right to require additional testing, at any time, to confirm or further investigate a suspected fault. All costs incurred shall be on the MANUFACTURER's account. In no case shall any action of the MEW, or his Inspector, relieve the MANUFACTURER of his responsibility for material, design, quality, or performance of the materials concerned. Inspection and tests performed/witnessed by the MEW's Inspector shall in no way relieve the MANUFACTURER of his obligation to perform the required inspection and tests. Inspection by the MEW's inspector shall be restricted to the following:

- Visual examination and dimensional check of the process connection
- Verification of testing as mentioned under factory testing
- Verification of type of protection certificate or declaration

- Verification of material certificates
- Verification of NACE compliance

The MEW may, at his discretion, appoint a Third Party Inspection Agency to carry out inspection on behalf of, or together with, the MEW's Inspector.

9 TEST CERTIFICATES

The MANUFACTURER shall submit the following certificates in accordance with EN10204 3.1.

a) Hydrostatic test certificates
b) Material test certificate (MIL certificate) for wetted parts.
c) Test report for class of enclosure.
d) Calibration reports for all transmitters.

The VENDOR shall supply a works certificate issued and signed by the MANUFACTURER's inspection, laboratory personnel, or other appropriate responsible employee. The inspection or other employee signing the certificate must be independent of the MANUFACTURER's production department.

The works certificate shall contain numerical results of chemical, electrical and mechanical tests. The type and extent tests shall be as described by the specification for the particular material involved.

In addition, the certificate shall include all information regarding customer, number of order, works number, type and quantity of materials. The production, process heat treatment, and other relevant features, if not limited or prescribed by the material specification should also be included

The test certificate shall confirm that satisfactory testing has been carried out. Manufacture's serial number shall be quoted on all certificates. The certificates shall indicate the method of marking and the material shall be marked in such a manner that it can be traced back to the certificate and test relevant to it.

All non-destructive testing shall be fully certified.

10 SPARE PARTS

The MANUFACTURER shall provide the recommend spare parts on the following basis:

- Commissioning spares
- Two (2) years operation spares

The commissioning and operations spares to be handed over to MEW store.

Parts data shall be listed on proper form and be supplemented with appropriate drawings / bulletins identifying all parts in their respective position".

MANUFACTURER shall provide the Standard Recommended Spare Parts list (for maintenance) form for Spare Parts and Maintenance Data.

The price for the spare parts shall be included in the respective item of the pressure transmitter BOQ.

11 PREPARATION FOR SHIPMENT

VENDOR shall be responsible for the design, supply, assembly and application of all preservation & packaging required for safe transportation, handling and storage of Level Transmitter supplied under this order.

All openings shall be sealed and threaded connections shall be protected with moulded plastic screwed plugs or caps. The Transmitters shall be packed in cartons or crates, suitable for sea shipment in such a way that corrosion and damage to parts and paint is avoided.

Each individual carton or box shall be marked with the Project Name & Code, Purchase Order No., Tag No. and MEW's Name and Address, on the top and side of the carton / crate.

Initial spares shall be packed separately from the main equipment. The box or case shall be clearly marked 'Initial Spares', Project Name & Code, Purchase Order No. and Tag No. on the top and side of the carton. Furthermore each spare part shall have its part number clearly identified and attached.

VENDOR shall be entirely responsible for any claim arising, which is attributable to defective and / or insufficient packing.

Government of State of Kuwait
Ministry of Electricity and Water

Section 4C.10

Technical Specification for Chamber flood level Switches

Contents Summary

1 INTRODUCTION

This Specification defines the minimum requirements for the design, manufacture, testing and supply of flood Level Switches to be used for this Project.

2 REFERENCE DOCUMENTS

Reference has been made, in this Specification, to the latest edition of the following Codes, Standards, and Specifications:

2.1 Codes and Standards

ASME B 1.20.2	-	Pipe Threads General Purpose
ASME B 31.3	-	Chemical Plant & Petroleum Refinery Piping
BP RP 30-1	-	Instrumentation & Control – Design and Practice
BP RP 30-2	-	Instrumentation & Control – Selection and Use of Measurement Instrumentation
BP RP 32-1	-	Inspection and Testing of New Equipment in Manufacture
IEC 60529	-	Degrees of Protection provided by Enclosures (IP Code)
ISO 9000	-	Quality Management and Quality Assurance Standards.
NACE MR 01-75	-	Standard Material Requirements Sulphide Stress Cracking Resistant Metallic Materials for Oilfield Equipment.

3 ORDEROF PRECEDENCE

In case of conflict between the requirements of this Specification and the referenced codes, standards, and specifications, the following precedence shall apply:

1. This Specification.
2. Project Specifications.
3. Other International Codes and Standards.

4 ENVIRONMENTAL CONDITIONS

The environmental of Kuwait, is severe on all equipment and must be considered carefully before design and procurement of plant and equipment. It must be assumed that, unless otherwise specified, equipment may be subjected to sand and fine particle dust storms, sand laden winds, chemical contaminants, thunderstorms, heavy rain and extreme temperatures.

4.1 Temperature and Humidity

Summer maximum dry bulb temperature:	65°C,
shade Summer minimum wet bulb temperature:	28°C
Summer maximum average dry bulb temperature:	50°C
Summer maximum dry bulb temperature (Solar):	80°C

Soil temperature at 1.22m depth: maximum 35°C. minimum 17°C. A design of 40°C shall be used for cable system design calculations.

For electrical equipment design, ambient temperature shall be –3°C to 65°C for all indoor and outdoor equipment.

Except for as limited by coating on pipes, the surface design temperature (applicable) shall be 93°C for equipment and installation.

a) Direct Sunlight : Exposed metal black body maximum temperature due to solar radiation : 85°C

b) Shade Temperature : 55°C maximum
45°C average (1day)
–3°C minimum @ 100% RH

Note: All equipment and materials shall be suitable for this direct sunlight temperature unless installed in a protected environment. Sunshades shall be provided where appropriate.

c) Exposed white body maximum temperature : 63°C

d) Winter minimum dry bulb temperature : –3°C

e) Winter minimum average dry bulb temperature : 7°C

f) Winter minimum average wet bulb temperature : 3°C

g) Relative humidity maximum at: 55°C, 50% at 0°C, 100% varying from 6 to 100 %

Note: These dry and wet bulb temperatures shall be used for winter heating design purposes.

4.2 Atmospheric Conditions

The atmosphere is generally dusty and corrosive and in some areas may contain traces of hydrogen sulphide.

4.3 Sandstorms

Kuwait is subject to sandstorms, particularly during the summer months:

a) Ambient air range minus 3°C to plus 55°C

b) 16 grams dust per 100 cubic foot air.

c)

DustParticleSize (micron)	Wt%FineDust (Plus/minus 3%)
0-5	39
5-10	18
10-20	16
20-40	18
40-80	9

4.4 Wind Data

a) Maximum recorded wind speed: 38 m/s

b) Design maximum wind speed: 45 m/s

c) Summary prevailing wind direction / speed: SE, 6 m/s (Burgan area)

d) Winter prevailing wind direction / speed: NW, 6 m/s (Burgan area)

e) Prevailing wind direction / speed: NNW, 6 m/s (North Kuwait)

f) Summer prevailing wind direction: NNW (North Kuwait)

g) Winter prevailing wind direction: SSE (North Kuwait)

4.5 Rainfall

Kuwait is subject to thunderstorms and heavy rainfall.

a) Annual maximum: 200mm

b) 115 mm/h, falling uniformly for 30 minutes

4.6 Seismic Data

Kuwait is not subject to earthquakes, and is therefore not an active seismic zone.

5 QUALITY ASSURANCE

The MANUFACTURER shall operate a Quality System meeting the requirements of the relevant Part of ISO 9000.

The MANUFACTURER shall ensure that his Sub-SUPPLIERs operate a quality system meeting the specified conformance criteria to ISO 9000. The MANUFACTURER's quality system shall be subject to the MEW's approval prior to commitment to a Purchase Order.

Major Sub-SUPPLIERs shall be subject to identical approvals. The MEW reserves the right to conduct a Quality Audit at the MANUFACTURER's/Sub-SUPPLIER's facilities at any stage during manufacture.

6 DESIGN AND CONSTRUCTION

6.1 General

The intent of this section is to describe the minimum acceptance parameters for the design/manufacture and supply of level Switches for chamber flood.

The Level Switches shall be suitable for continuous operation in the submerged conditions under the waste water, service water and brackish water. They shall meet the environmental conditions outlined in Section.

Unless otherwise specified the enclosure ingress protection shall be at least IP68.

6.2 Design and Construction

The construction of the Level switches shall conform to ISA std. standards.

High Level Switches shall be certified and enclosure ingress protection shall be at least IP 68.

6.3. **Material Requirements**

The float shall be manufactured to function at maximum pressure and temperature condition specified in the related Data Sheet. The float shall be suitable to provide accurate indication for the operating specific gravity.

Below ground chambers, basements and sumps pit shall each be provided with a chamber flooding alarm provided by a float switch or conductivity electrode system. The flooding alarms shall be transmitted to the station control system. Level switches of the buoyancy type shall consist of a mercury switch, specified with pole, hermetically sealed, gold plated micro-switch. The level switch cable shall be 3 cores x 1.5 sq. mm enclosed in a non-corrosive material. A balance weight shall also be incorporated in the switch to counteract the buoyancy effects for the specific gravity of the particular fluid. The connecting cable shall be sealed into the switch. The Level switch shall be adequate protected against corrosion and mechanical damage and the ingress of water, sand dust and vermin etc. The flood switches to be provided with adequate (SS 316L) support inside the valve chamber. The chamber flood switches shall be hardwired to main junction via. SS316L Local junction (IP68) box to the redundant DCS I/O module and configure into control system.

The float material, counter weight and all accessories materials shall be SS316L.

The instrument wetted parts materials shall be suitable for NACE Standard MR 01-75.

Instrument data sheets to be prepared as per ISA–20–1981 STANDARD (ISA Forms S20.20a and 20.20b and Instructions for ISA Forms S20.40a and 20.40b), and submitted to MEW approval, before procurement of materials.

6.4 Painting

Where applicable, painting shall be as per MANUFACTURER own standard, with MEW's approval.

6.5 Tagging

Each Level Switch shall be provided with a stainless steel identification nameplate, with all data clearly and deeply engraved, and permanently attached by means of rivets or pins. The following data shall be provided as a minimum:

Instrument tag number
MANUFACTURER's name or trademark
MANUFACTURER's model Number
MANUFACTURER's serial number
Maximum pressure rating including units
Range including units of measure
Float material

All information on the nameplate shall be die-stamped or deep engraved.

7 DOCUMENTATION

7.1 Documentation Required for approval.

- Full technical literature for the equipment offered.
- An unqualified statement of compliance with the specification and data sheet requirements.
- A list of all accessory items together with MANUFACTURER's name and part number.
- The VENDOR shall provide a completed copy of the instrumentation data sheets with all changes entered.
- Data sheet
- Loop diagram
- Hookup diagram
- Assembly drawings with overall dimensions.
- Detailed sectional drawings showing all parts with reference numbers and materials specification.
- Detailed drawings and catalogue manuals for various items.
- Welding, Heat Treatment, Inspection and Testing Procedure.
- Details of the proposed painting system as per manufacture standard.
- Quality Control Manual and Quality Control Plan.

Manufacture of the Level Switches shall commence only after approval of the above documents. Once approval has been given by the MEW, any changes in design, material or method of manufacture shall be notified in writing to the MEW. MEW approval shall be obtained for all changes before the Level switches are manufactured.

On receipt of written approval, the MANUFACTURER shall submit to the MEW all approved documents as listed above.

Prior to shipment, the MANUFACTURER shall submit the test certificates as

listed in this Specification.

Documents shall be in the English Language.

8 INSPECTION AND TESTS

8.1 General

The SUPPLIER shall meet the inspection and testing requirements of BP RP 32-1, Procedure 11 – Instrumentation and Control Equipment.

8.2 Factory Testing

Each Level Gauge surge vessel, and diesel tanks shall be subject to a hardness test as NACE MR 01-75.

Each Level Gauge for surge vessel, and diesel tanks shall be hydrostatically pressure tested at minimum 1.25 times the chamber rating.

8.3 Factory Inspection

If specified in the purchase order, the MEW's designated inspector before dispatch shall inspect the level switches unless otherwise specified. Inspection by the MEW's inspector shall be as a minimum to the following:

Visual examination and dimensional check

Verification of testing as mentioned under approved factory testing procedures

Verification of material certificates

Verification of NACE MR 01-75 compliance

9 TESTCERTIFICATES

The MANUFACTURER shall submit the certificates in accordance with EN10204 3.1

A material test certificate shall be provided and incorporated into a works certificate as described below.

The VENDOR shall supply a works certificate issued and signed by the MANUFACTURER's inspection, laboratory personnel, or other appropriate responsible employee. The inspection or other employee signing the certificate must be independent of the MANUFACTURER's production department.

The works certificate shall contain numerical results of chemical and mechanical tests. The type and extent of the tests shall be as described by the Specification for the particular material involved.

In addition, the certificate shall include all information regarding customer, number of order, works number, type and quantity of materials. The production, process heat treatment, and other relevant features if not limited or prescribed by the material specification should also be included.

The test certificate shall confirm that satisfactory testing has been carried out. MANUFACTURER's serial numbers shall be quoted on all certificates.

The certificates shall indicate the method of marking and the material shall be marked in such a manner that it can be traced back to the certificate and test relevant to it.

All non-destructive testing shall be fully certificated.

Functional test certificates shall be provided in accordance with specification. Official

type certificates shall be forwarded within one week of test completion.
MEW shall approve test certificates prior to dispatch. Approval by the MEW inspector shall not relieve the SUPPLIER responsibility to comply with the purchase order and this specification.

10 SPAREPARTS

The MANUFACTURER shall provide recommend spare parts on the following basis:

Commissioning spares
Two (2) years operation spares

The commissioning and operations spares to be handed over to MEW store.

Parts data shall be listed on proper form and be supplemented with appropriate

drawings / bulletins identifying all parts in their respective position".

MANUFACTURER shall provide the Standard Recommended Spare Parts list (for maintenance) form as per Attachment for Spare Parts and Maintenance Data.

The spare parts as specified in the BOQ Should not used for the commissioning and two years operations.

11 PREPARATION FOR SHIPMENT

VENDOR shall be responsible for the design, supply, assembly and application of all preservation & packaging required for safe transportation, handling and storage of Level Switches supplied under this order.

All openings shall be sealed and threaded connections shall be protected with moulded plastic screwed plugs or caps. The Level Switches shall be packed in cartons or crates, suitable for sea shipment in such a way that corrosion and damage to parts and paint is avoided.

Each individual carton or box shall be marked with the Project Name & Code, Purchase Order No., Tag No. and MEW's Name and Address, on the top and side of the carton / crate.

Initial spares shall be packed separately from the main equipment. The box or case shall be clearly marked 'Initial Spares', Project Name & Code, Purchase Order No. and Tag No. on the top and side of the carton. Furthermore each spare part shall have its part number clearly identified and attached.

VENDOR shall be entirely responsible for any claim arising, which is attributable to defective and / or insufficient packing.

Government of State of Kuwait
Ministry of Electricity and Water

Section 4C.11

Technical Specification for Electro-Magnetic Flow meter

ContentsSummary

1 INTRODUCTION

This Specification defines the minimum requirements for the design, manufacture, testing and supply, modify and install of Electro Magnetic Flow meter used for the Project.

2 REFERENCE DOCUMENTS

Reference has been made, in this specification, to the latest edition of the following Codes, Standards, and Specifications:

2.1 Codes and Standards

API MPMS, Chap 5, Section 5 - Fidelity & Security of flow measurement pulsed data transmission systems

API MPMS, Chap 11.1 - Volume correction tables

API MPMS, Chap 11.2 - Compressibility factors for hydrocarbons

API MPMS, Chap 21, Section 2 - - Flow measurement electronic systems

API 1104 - Welding of Pipelines and Related Facilities

ASME Section VIII, Division 1 - Boiler and Pressure Vessel Code

BP RP 30-1 - Instrumentation & Control – Design and Practice

BP RP 30-2 - Instrumentation & Control – Selection and Use of Measurement Instrumentation

BP RP 32-1 - Inspection and Testing of New Equipment in Manufacture

BS EN ISO 1461 - Hot dip galvanized coatings on fabricated Iron and Steel articles - Specification and Test Methods.

BS EN 60079-14 - Code of Practice for Selection, Installation and Maintenance of Electrical Apparatus for Use in Potentially Explosive Atmospheres

BS EN 10204 - Metallic Products – Types of Inspection Documents

BASEEFA - British Approvals Services for Electrical Equipment in Flammable Atmosphere

IEC 60529 - Degrees of Protection provided by Enclosures (IP Code)

IEC 60770 - Transmitters for Use in Industrial Process Control System

IP 252/76 Part XIII - Fidelity and Security of Measurement Data Transmission System

ISO 4124 - Liquid Hydrocarbons – Dynamic measurement – statistical control of volumetric metering systems

ISO 9000	-	Quality Management and Quality Assurance Standards.
OIML – R117	-	Measuring Systems other than Water
OIML - P17	-	Guide to the expression of uncertainty in measurement (GUM)
MSS SP-53	-	Quality Standard for Steel Castings and Forgings for Valves, Flanges and Fittings and Other Piping Components-Magnetic Particle Exam Method
NACE MR0175	-	Standard Material Requirements Sulfide Stress Cracking Resistant Metallic Materials for Oilfield Equipment.

2.2 Project Specifications

Particular Spec -

3 ORDER OF PRECEDENCE

In case of conflict between the requirements of this specification and the referenced codes, standards, and specifications, the following precedence shall apply:

1. This Specification.
2. Project Specifications.
3. Other International Codes and Standards.

4 DEFINITIONS

To match the definitions, as used in this Specification, the following terminology shall be used:

"CLIENT", "MEW"	:	Government of State of Kuwait Ministry of Electricity and Water

5 ENVIRONMENTAL CONDITIONS

The environmental of Kuwait, is severe on all equipment and must be considered carefully before design and procurement of plant and equipment. It must be assumed that, unless otherwise specified, equipment may be subjected to sand and fine particle dust storms, sand laden winds, chemical contaminants, thunderstorms, heavy rain and extreme temperatures.

5.1 Temperature and Humidity

Summer maximum dry bulb temperature: Summer 65°C, shade

minimum wet bulb temperature: 28°C

Summer maximum average dry bulb temperature: Summer 50°C

maximum dry bulb temperature (Solar): 80°C

Soil temperature at 1.22m depth: maximum 35°C. minimum 17°C.

A design of 75°C shall be used for cable system design calculations.

For electrical equipment design, ambient temperature shall be –3°C to 50°C for all indoor and outdoor equipment shall be –3°C to 70°C for the Electromagnetic flow meter sensor and transmitter with all accessories.

Except for as limited by coating on pipes, the surface design temperature (applicable) shall be 93°C for equipment and installation.

a) Direct Sunlight : Exposed metal black body maximum temperature due to solar radiation : 85°C

b) Shade Temperature : 55°C maximum 45°C average (1day) –3°C minimum @ 100% RH

Note: All equipment and materials shall be suitable for this direct sunlight temperature unless installed in a protected environment. Sunshades shall be provided where appropriate.

c) Exposed white body maximum temperature : 63°C

d) Winter minimum dry bulb temperature : –3°C

e) Winter minimum average dry bulb temperature : 7°C

f) Winter minimum average wet bulb temperature : 3°C

Note: These dry and wet bulb temperatures shall be used for winter heating design purposes.

g) Relative humidity maximum at: 55°C, 50% at 0°C, 100% varying from 6 to 100%

5.2 Atmospheric Conditions

The atmosphere is generally dusty and corrosive and in some areas may contain traces of hydrogen sulphide.

5.3 Sandstorms

Kuwait is subject to sandstorms, particularly during the summer months:

a) Ambient air range minus 3°C to plus 55°C

b) 16 grams dust per 100 cubic foot air.

c)

DustParticleSize (micron)	Wt%FineDust (Plus/minus 3%)
0-5	39
5-10	18
10-20	16
20-40	18
40-80	9

5.4 Wind Data

a) Maximum recorded wind speed: 38 m/s

b) Design maximum wind speed: 45 m/s

c) Summary prevailing wind direction / speed: SE, 6 m/s (Burgan area)

d) Winter prevailing wind direction / speed: NW, 6 m/s (Burgan area)

e) Prevailing wind direction / speed: NNW, 6 m/s (North Kuwait)

f) Summer prevailing wind direction: NNW (North Kuwait)

g) Winter prevailing wind direction: SSE (North Kuwait)

5.5 Rainfall

Kuwait is subject to thunderstorms and heavy rainfall.

a) Annual maximum: 200mm.

b) 115 mm/h, falling uniformly for 30 minutes

5.6 Seismic Data

Kuwait is subject to earthquakes, and is therefore an active seismic zone.

6 QUALITY ASSURANCE

The MANUFACTURER shall operate a Quality System meeting the requirements of the relevant Part of ISO 9000.

The MANUFACTURER shall ensure that his sub-SUPPLIERs operate a quality system meeting the specified conformance criteria to ISO 9000. The MANUFACTURER's quality system shall be subject to the MEW approval prior to commitment to a Purchase Order.

Major Sub-SUPPLIERs shall be subject to identical approvals. The MEW reserves the right to conduct a Quality Audit at the MANUFACTURER's/Sub- SUPPLIER's facilities at any stage during manufacture.

7 DESIGN AND CONSTRUCTION

7.1 General

Electro-Magnetic flow measurement loop comprising of sensor head and remote mounted data logging transmitter having smart type with Hart protocol and its accessories to be supplied and installed in-line with pipeline as per approved Piping drawings. The new electromagnetic flow meter shall measure the quantity of water flow supplied by pipeline mains. The MFM shall be of proven reliable type, five years stability and can withstand ambient / static head / surge conditions.

The system shall be an open system composed of standards-based technology with field devices over HART networks.

The field-device shall connect to the fault tolerant redundant process control I/O modules through signal splitters and Panel mount HMI workstation shall be monitored.

Construction

Electromagnetic flow meters shall operate on electromagnetic Induction principles and shall consist of a detector head and signal convener system, which shall comply with BS 5792 or equivalent as subject to the Engineer approval.

The flow metering system shall produce digital outputs proportional to volume, rate of flow, alarm 1 and alarm 2.

The detector head shall have a stainless steel metering tube and non- conductive abrasion-resistant lining to suit the fluid being metered.

Sensor	Specifications
Body Housing	SS316L
Flanges	SS316L
Metering tube material	SS 316 L
Electrode material	SS316L
Electrode Grounding & Earthing Ring	SS316L
Liner material	EPDM or Elastomer or Hard rubber WRC approved for Potable water
No of Electrodes	4 (2 measuring +2 reference)
Enclosure Protection.	IP 68
Ambient temperature rating	-20 to +75 deg. C
Empty pipe detection	Required
Sensor cable length to remote mount transmitter	Min.30 Meter potted on sensor side.
Calibration	5 points calibration with Pressure Test
Pressure Rating	PN16
End Connection Flange drilling	In accordance with process flange as per piping spec.
Certificate	As per EN10204 3.2 std.
Tag plate material	SS316
Remote mount Transmitter	
Type	Remote Mount type inside GRP (800x800x500mm)Housing.
Housing Materials	Copper free Di-cast aluminum or SS316L as per vendor std.
Power supply	240v AC from UPS, through power isolator locate inside GRP
Output	Smart type Hart protocol (4-20mA)
Digital output	4 (C, NO, NC)
Display	2 lines 9 Digit LCD Display
Accuracy	+/- 0.2% or better
Data logger	Yes , for min 365 days
Enclosure Protection.	IP 65
Ambient temperature rating	-20 to +70 deg.C
Tag plate	SS316
Certificate	As per EN10204 3.1 std.

The datalogger / transmitter shall be installed inside GRP Instrument housing (800x800x400mm, min). The price for the GRP IHB item shall be included in the respective item of transmitter bill of quantity.

The material of construction for the wetted parts shall be suitable for Distilled, Fresh, Brackish water service and other Chemicals (caustic, chlorine) service and shall meet the requirements of NACE MR-01-75 (latest edition).

For potable water applications the lining material shall be WRC approved hard rubber.

Detector heads shall be flanged to BS 4504. The flanges shall be compatible with those specified for the associated pipe work.

Detector heads shall be fitted with an anti-roll system to prevent damage during storage.

Power and signal cables to the detector head shall either be factory sealed or shall be spotted on site.

"Potting" shall take place immediately after installation, or other measures employed to ensure that no water or foreign matter enters the terminal enclosure during the Interim period between Installation and wiring.

Detector heads installed within a chamber shall have a degree of protection IP 68 and shall be suitable for indefinite submersion under a head of water equal to the chamber depth or 3 meters whichever is greater.

Detector heads shall be installed on steel cradle or concrete plinth with at least 10 pipe diameters of straight pipe upstream and 5 diameters downstream unless otherwise recommended by manufacturer and agreed by the Engineer.

When fitted in lined non-metallic or internally coated pipe work, the detector head shall have an Earthing electrode or corrosion- resistant Earthing rings.

The instrument and pipe work shall be designed and installed in such a way that air or other gases will not be trapped in or around the sensor.

The flow meter body shall be bonded by tinned copper braid links at each end to the adjacent pipe work to ensure a good connection between the body and the metered liquid.

If the pipework has cathodic protection, the manufacturer's recommendations for bonding and protecting the instrument and its signals shall be adhered to.
The signal converter shall be suitable for operation on a single phase 240V 50Hz power supply from redundant UPS, unless otherwise specified and shall provide a precise current input to the field winding of the detector head and shall convert the resultant signal from the electrodes to analogue and pulse outputs to comply with BS 5863. The signal processing facilities of the converter shall ensure that the output signals are

unaffected by interfering voltages, stratified flow, changes in fluid electrical conductivity within the limit stated, non-homogeneity of the fluid or the presence of ferrous particles. The instrument zero shall be maintained automatically without interruption of flow or output signals. The zero and output signals shall be unaffected by partly fouled electrodes.

The flow meter should operate in lower or higher value of conductivity in distilled water service.

The following signal converter features shall be provided as a minimum. Additional requirement may be stated elsewhere in the specification:

Signals on alarm:- Last valued output value, last good value, failsafe value, status bad, wrong value, pipeline leakage-excess flow alarm.

1) Pulsed field excitation
2) Scaled pulse output for integration counter drive
3) Integral display of current flows and integrated quantity
4) Galvanic isolation between each output circuit and between the electrode circuit and the output circuit.
5) Key entry for basic parameters, range, etc. .
6) Commissioning and rescaling to require no special programming knowledge.
7) An adjustable low flow cut-off
8) Self-diagnosis and remote diagnostic capability.
9) Terminals to have a compartment separate from electronic components.
10) Minimum fluid conductivity 5 micro-Siemens /cm or less;
11) All parts in contact with the medium shall comply with relevant standards and codes.
12) Continuously adjustable velocity range Setting 03 to 10 m or better.

Performance

The following performance shall be as a minimum; superior standard shall be met where stated elsewhere in the specification or where so required by metering and/or control requirements.

Overall flow system accuracy for local and remote display (including pulse counter).

True Flow as % of Full	Maximum Error Scale Setting
60 to 100%	± 0.2% of true value
10 to 50%	± 0.2% of true value
5 to 10%	± 0.2% of true value

Repeatability Not exceeding ± 0.2% of true value

Turn Down Ratio 1000: 1

Each converter shall be completely interchangeable with any other electromagnetic flow meter converter of the same design. Calibration checking shall require neither auxiliary test meter nor simulator.

Plant mounted signal converter enclosures shall have a degree of protection of not less than IP68 to BS EN 60529. Signal converters installed within an instrument panel located in a building may be of the rack-mounted type having a degree of protection not less than IP65. Signal converters shall not be located in flow meter chambers or areas subject to flooding. Secure the interconnection cable run or route the cable in a galvanized conduit.

Signal wiring terminals shall be of the screw type or field bus manufacturer standard All terminals for electrical connections shall be clearly numbered. The terminals polarity, where applicable, shall be permanently marked.

Transmitters with flying leads are not acceptable.

7.2 Painting

Where applicable, painting shall as per MANUFACTURER own standard, with MEW approval.

7.3 Tagging

EFM Flow Meters shall be provided with an identification plate, with all data clearly stamped on a corrosion resistant plate permanently attached to each instrument by means of rivets or pins and shall indicate, as a minimum, the following:

- Name of the MANUFACTURER or Trade Mark
- Manufacturer's Model Number
- Instrument Tag Number
- Serial Number
- Year of Manufacture
- Range & Calibration (including units of measurement)
- Body Type / Material and Rating (including units)
- Design Code
- Electrical safety (type of protection)
- Output signal

8 PERFORMANCE GAURENTEES

The service life of the EMF meters, shall be minimum 10 years; however periodic inspection, withdrawal and checking of each EFM flow meter shall be performed as a preventative maintenance procedure.

The EMF meters shall be capable of continuous operation at flow rate ranges, within the limits of repeatability and linearity, and without detriment to the service life.

The EMF meters shall be capable of service under limited conditions of surge, hydraulic shock (hammer) or sudden flow reversal without detriment to the service life repeatability or linearity as specified above.

In the event that a EMF meter was subjected to a flow rate exceeding this figure, the duration and degree of over-speeding shall be taken into account when evaluating the performance of that meter. Generally, over-speeding of any EMF meter would obviate the requirement for that meter to meet the performance guarantee requirements.

The performance guarantee period shall be (2) year after successful conclusion of commissioning and handing over the system. Should the performance of a EMF meter

fail to comply with the requirements of this specification during the guarantee period, then the Contractor/VENDOR shall replace that EMF meter with another of the same design, free of charge including delivery and installation.

9 DOCUMENTATION

9.1 Documentation Required Approval

- Full technical literature for the equipment offered.

- An unqualified statement of compliance with the specification and data sheet requirements.

- A list of all accessory items together with MANUFACTURER's name and part number.

- The VENDOR shall provide a completed copy of the instrumentation data sheets with all changes entered.

- Assembly drawings with overall dimensions, including the flow register and all features. Complete dimensional details of the support foot (where applicable) shall be indicated in these drawings.
- Detailed sectional drawings showing all parts with reference numbers and materials specification.

- Detailed drawings and catalogue manuals for various items.
- ISA filled data sheets from OEM.
- Electrical hook-up drawings.
- Instrument loop diagrams, interconnection diagrams.
- Design Calculations.
- Combined uncertainty calculations for the entire metering system.
- Welding, Heat Treatment, Inspection and Testing Procedure.
- Quality Control Manual and Quality Control Plan.

Manufacture of the EMF meter shall commence only after approval of the above documents. Once approval has been given by the MEW, any changes in design, material or method of manufacture shall be notified in writing to the MEW. MEW approval shall be obtained for all changes before the equipment is manufactured.

On receipt of written approval, the MANUFACTURER shall submit to the MEW all approved documents as listed above.

Prior to shipment, the MANUFACTURER shall submit the test certificates as listed in this Specification.

Documents shall be in the English Language.

10 INSPECTION AND TESTS

The MANUFACTURER shall appoint a reputable Third Party Inspection Agency (i.e. BVQI, Lloyds, DNV or from MEW approved inspectors list), to carry out all inspection and tests as per the requirements of this specification and the relevant codes and standards, at his works prior to shipment. The Third Party Inspection Agency shall be approved by the MEW prior to his appointment. The inspection and tests shall be as a minimum, but not be limited to, the following:

- Visual Inspection.
- Dimensional checks on all EMF Meters shall be carried out as per the drawings approved by the MEW.
- Verification of type of protection certificate or declaration.
- Verification of EMF Flow Meters accuracy.

a. The accuracy of test equipment shall be one order of accuracy higher than the accuracy of instrumentation under test. All test equipment shall have a Calibration Certificate issued by a recognized organization less than one year old. This applies particularly to test pulse generators/counters necessary for FAT testing of all flow registers.

b. An industry approved independent test authority shall certify the prover used for EMF Meter testing.

c. All EMF meters shall be individually flow tested and proved against the prover supplied at their rated maximum and minimum flows and five other points at specified intervals between maximum and minimum. Each test shall consist of five consecutive runs, the results of which must be within ±
0.02% of the average pulse counts.

d. The linearity of the tests must also be within the specified limits.

e. Measurements also shall be made and reported for pressure drop across EMF meter and pressure drop across prover.

- For mechanical parts, chemical composition and mechanical properties,

including hardness, shall be checked as per relevant material standards and this specification, for each heat of steel used.

• Non-Destructive examination of individual EMF Meters material and components consisting of, but not limited to, castings, forgings and assembly welds shall be carried out by the MANUFACTURER.

• Body castings of the EMF Meters shall be radiographically examined on 100% of their surface of critical areas. All castings shall be subject to wet magnetic particle inspection on 100% of their internal surfaces.

• All EMF Meters, with bodies fabricated from forgings shall be ultrasonically examined in critical areas. All forgings shall be subject to wet magnetic particle inspection on 100% of the forged surfaces.

• Full inspection by radiography shall be carried out on all welds of pressure containing parts.

• Welds, which in the MEW opinion cannot be inspected by radiographic methods, shall be inspected by ultrasonic or magnetic particle means. Procedure and acceptance criteria shall be as per ASME Sec. VIII Appendix U and Appendix VI respectively.

• All EMF Meters shall be hydrostatically tested. During pressure testing, EMF Meters shall not have sealant lines and other cavities filled with sealant, grease or other foreign material. After pressure testing and acceptance, EMF Meters shall be thoroughly drained and dried. The internal surfaces shall be suitable water service anticorrosion fluid. The forged items or items formed by welding into a pressure enclosure shall be hydrostatically tested at 1.5 times the rating of flanges.

The MEW reserves the right to perform stage-wise inspection and witness tests at the MANUFACTURER's Works prior to shipment. The MANUFACTURER shall give reasonable access and facilities required for inspection to the MEW Inspector.

The MEW reserves the right to require additional testing, at any time, to confirm or further investigate a suspected fault. The cost incurred shall be to the MANUFACTURER's account.

In no case shall any action of the MEW or his Inspector relieve the MANUFACTURER of his responsibility for material, design, quality or operation of EMF Meters. Inspection and tests performed/witnessed by the MEW Inspector shall in no way relieve the MANUFACTURER's obligation to perform the required inspection and tests.

11 TEST CERTIFICATES

The MANUFACTURER shall submit the following certificates in accordance with EN10204 3.2 for EMF Meter and 3.1 for Flow Register.

a) Mill test certificates relevant to the chemical analysis and mechanical properties of the materials used for the EMF Meters construction as per the relevant standards.

b) Report on heat treatment carried out.

c) Test certificates of hydrostatic and pneumatic tests complete with duration and pressure records of each test.

d) Test reports of radiography, ultrasonic, MPI and DP inspection.

e) All other test reports and certificates as required by relevant standards and this Specification.

f) Test certificates for the electrical components of the control circuit.

g) Hazardous area certificate

h) Test report for class of enclosure.

i) Calibration reports and certificate of compliance issued by an OIML accredited internationally recognized Weights and Measures Institute (NMI) for all EMF Flow Meters.

The VENDOR shall supply a works certificate issued and signed by the MANUFACTURER's inspection, laboratory personnel, or other appropriate responsible employee. The inspection or other employee signing the certificate must be independent of the MANUFACTURER's production department.

The works certificate shall contain numerical results of chemical, electrical and mechanical tests. The type and extent tests shall be as described by the specification for the particular material involved.

In addition, the certificate shall include all information regarding customer, number of order, works number, type and quantity of materials. The production, process heat treatment, and other relevant features, if not limited or prescribed by the material

specification should also be included

The test certificate shall confirm that satisfactory testing has been carried out. Manufacture's serial number shall be quoted on all certificates. The certificates shall indicate the method of marking and the material shall be marked in such a manner that it can be traced back to the certificate and test relevant to it.

All non-destructive testing shall be fully certified.

12 SPARE PARTS

The MANUFACTURER shall provide the recommend spare parts on the following basis:

- Commissioning spares
- Two (2) years operation spares

The commissioning and operations spares to be handed over to MEW store.

Parts data shall be listed on proper form and be supplemented with appropriate drawings / bulletins identifying all parts in their respective position".

MANUFACTURER shall provide the Standard Recommended Spare Parts list (for maintenance) form for Spare Parts and Maintenance Data.

The price for the spare parts shall be included in the respective item of the Electromagnetic flow meter BOQ for commissioning and two years operational.

13 PREPARATION FOR SHIPMENT

VENDOR shall be responsible for the design, supply, assembly and application of all preservation & packaging required for safe transportation, handling and storage of EMF Flow Meters supplied under this order.

All openings shall be sealed and threaded connections shall be protected with moulded plastic screwed plugs or caps. The EMF Flow Meters shall be packed in cartons or crates, suitable for sea shipment in such a way that corrosion and damage to parts and paint is avoided.

Each individual carton or box shall be marked with the Project Name & Code, Purchase Order No., Tag No. and MEW Name and Address, on the top and side of the carton / crate.

Initial spares shall be packed separately from the main equipment. The box or case shall be clearly marked 'Initial Spares', Project Name & Code, Purchase Order No. and Tag No. on the top and side of the carton. Furthermore each spare part shall have its part number clearly identified and attached.

VENDOR shall be entirely responsible for any claim arising, which is attributable to defective and / or insufficient packing.

Government of State of Kuwait
Ministry of Electricity and Water

Section:- 4C.12

Technical Specification for Temperature Elements and Transmitters

Contents Summary

1 INTRODUCTION

This Specification defines the minimum requirements for the design, manufacture, testing and supply of Temperature Elements and Transmitters to be used for fresh water Pipelines temperature measurement for the Project.

2 REFERENCEDOCUMENTS

Reference has been made, in this Specification, to the latest edition of the following Codes, Standards, and Specifications:

2.1 Codes and Standards

ANSI B 31.3 - Chemical plant and Petroleum Refinery piping

ANSI B 1.20.2 - Pipe Threads General Purpose

API PMC 40-1 - Bimetallic Thermometers

ASME Section VIII and XI - Boiler and Pressure Vessel Code

BP RP 30-1 - Instrumentation and Control – Design and Practice.

BP RP 32-1 - Inspection and Testing of New Equipment in Manufacture. BS 1904

- Specification for Industrial Platinum Thermometer Sensors

BS EN 60079-14 - Code of Practice for Selection, Installation and Maintenance of Electrical Apparatus for Use in Potentially Explosive Atmospheres

BS EN 10204 - Metallic Products – Types of Inspection Documents

BASEEFA - British Approvals Services for Electrical Equipment in Flammable Atmosphere

IEC 60529 - Degrees of Protection Provided by Enclosures (IP Code) IEC

60751 - Industrial Platinum Resistance Thermometer Sensors

IEC 60770 - Transmitters for Use in Industrial-Process Control Systems

ISO 9001 - Quality Systems – Model for Quality Assurance in Design, Development, Production, Installation and Service

NACE MR-01-75 - Sulphide Stress Cracking Resistant Metallic Materials for Oil Field Equipment

2.2 Project Specifications and Drawings.

2.3 ORDER OF PRECEDENCE

In case of conflict between the requirements of this specification and the referenced codes, standards, and specifications, the following precedence shall apply:

1. This Specification.
2. Project Specifications.
3. Other International Codes and Standards.

3 DEFINITIONS

To match the definitions, as used in this Specification, the following terminology shall be used:

"CLIENT", "MEW"	:	Government of State of Kuwait Ministry of Electricity and Water

4 ENVIRONMENTALCONDITIONS

The environmental of Kuwait, is severe on all equipment and must be considered carefully before design and procurement of plant and equipment. It must be assumed that, unless of otherwise specified, equipment may be subjected to sand and fine particle dust storms, sand laden winds, chemical contaminants, thunderstorms, heavy rain and extreme temperatures.

4.1 TemperatureandHumidity

Summer maximum dry bulb temperature : Summer	65°C, shade
minimum wet bulb temperature :	28°C
Summer maximum average dry bulb temperature :	50°C
Summer maximum dry bulb temperature (Solar):	80°C

Soil temperature at 1.22m depth: maximum 35°C. minimum 17°C. A design of 40°C shall be used for cable system design calculations.

For electrical equipment design, ambient temperature shall be –3°C to 50°C for all indoor (inside a/c room) and outdoor equipment shall be –3°C to 85°C for the

pressure transmitter with all accessories.

Except for as limited by coating on pipes, the surface design temperature (applicable) shall be 93°C for equipment and installation.

a) Direct Sunlight : Exposed metal black body maximum temperature due to solar radiation : 85°C

b) Shade Temperature : 55°C maximum
45°C average (1day)
–3°C minimum @ 100% RH

Note : All equipment and materials shall be suitable for this direct sunlight temperature unless installed in a protected environment. Sunshades shall be provided where appropriate.

c) Exposed white body maximum temperature : 63°C

d) Winter minimum dry bulb temperature: –3°C

e) Winter minimum average dry bulb temperature : 7°C

f) Winter minimum average wet bulb temperature : 3°C

Note : These dry and wet bulb temperatures shall be used for winter heating design purposes.

g) Relative humidity maximum at : 55°C, 50% at 0°C, 100% varying from 6 to 100%

4.2 AtmosphericConditions

The atmosphere is generally dusty and corrosive and in some areas may contain traces of hydrogen sulphide.

4.3 Sandstorms

Kuwait is subject to sandstorms, particularly during the summer months:

a) Ambient air range minus –3°C to 55°C

b) 16 grams dust per 100 cubic foot air.

c) Dust Particle Size (micron) — Wt% Fine Dust (Plus/minus 3%)

5-10	18
10-20	16
20-40	18
40-80	9

4.4 WindData

a)	Maximum recorded winds peed :	38 m/s
b)	Design maximum wind speed :	45 m/s
c)	Summary prevailing wind direction / speed :	SE, 6 m/s (Burgan area)
d)	Winter prevailing wind direction / speed :	NW, 6 m/s (Burgan area)
e)	Prevailing wind direction / speed :	NNW, 6 m/s (North Kuwait)
f)	Summer prevailing wind direction :	NNW (North Kuwait)
g)	Winter prevailing wind direction :	SSE (North Kuwait)

Rainfall Kuwait is subject to thunderstorms and heavy rainfall.

a) Annual maximum : 200mm.

b) 115 mm/h, falling uniformly for 30 minutes

4.5 SeismicData

Kuwait is not subject to earthquakes, and is therefore not an active seismic zone.

5 QUALITYASSURANCE

The MANUFACTURER shall operate a Quality System meeting the requirements of the relevant Part of ISO 9000.

The MANUFACTURER shall ensure that his Sub-SUPPLIERs operate a quality system meeting the specified conformance criteria to ISO 9000. The MANUFACTURER's quality system shall be subject to the MEW's approval prior to commitment to a Purchase Order.

Major sub-SUPPLIERs shall be subject to identical approvals. The MEW reserves the right to conduct a Quality Audit at the MANUFACTURER's/sub-SUPPLIER's facilities at any stage during manufacture.

6 DESIGN AND CONSTRUCTION

The Temperature Element type shall be as specified in the related Data Sheets.

The temperature transmitters shall be a "Smart" type suitable for both analogue and digital simultaneous transmission using open field bus protocol and have non-volatile configuration data storage. A self-diagnostic facility shall be provided.

The system shall be an open system composed of standards-based technology with field devices over smart with HART protocol, 2 wire system, 4-20mA/24vDC.

The field-device shall connect to the Process Control Units via. direct hardwired to the redundant DCS I/O modules via. Signal splitter.

The Temperature transmitter shall be of latest 'state-of the-art' technology using modern digital techniques for measurement, signal processing, configuration and self-diagnosis. Transmitter shall have digital display and advanced automatic programmable calibration features.

The Temperature transmitter shall be of proven reliable type, five years stability and can withstand ambient / static head / surge conditions. All accessories shall be included including sensor, thermo well, integrated digital local indication, field bus coupler, field bus power supply unit and local volume LCD indicator, etc.

The transmitter's design shall guarantee long lifetime and long re-calibration intervals, have very high reliability with ease of maintenance and shall comply with the industrial standards normally followed.

The Temperature Transmitter shall be remote mounted type and shall have a circuit for conversion of resistance / mV to current signals.

6.1 Element

The type of element and its installation shall ensure that the overall discrimination and accuracy of measurement shall be as specified in the related Data Sheets (refer to 6.14) for Temperature Elements and Transmitters.

Resistance Temperature Detector (RTD) shall be used as specified in the Data Sheets (refer to 6.14)for Temperature Element and Transmitters.

All application shall use duplex element RTD even if only one signal is required.

RTD characteristic shall comply with IEC 60751 (BS 1904). The RTD shall be three wire types and shall have a resistance of 100 ohms at 0oC.

The temperature element flying leads shall be connected to transmitter terminals directly.

6.2 Output

Transmitter output shall be both 4-20 mA with superimposed digital signal complying with open digital field bus communication HART protocol

Power supply:-
Redundant Isolated 24Vdc Power supply, loop powered.

6.3 Electronics

The transmitter electronics shall be solid-state with appropriate 'smart' circuitry. Printed circuit boards (PCB) shall be of a replaceable modular construction, be hermetically sealed or protected by a corrosion resistant coating (tropicalised).

PCB shall be plug-in type and vibration free supported. Signal wiring terminals and electronics shall be housed in separate compartments, so that the electronics remain sealed during electrical connection to the signal cable.

6.4 Calibration/Configuration

It shall be possible to perform on-line and remote set point configuration/calibration of the transmitter via a Hand Held Communicator (HHC) using HART protocol. HHC shall be of easy to use and shall be suitable for use in the area classification as specified for transmitters in the related Data Sheets. The fieldbus output of the transmitter shall not be affected during communication with the HHC.

Online Configurability

The system shall support the making of online configuration changes such as calibration, up loading and down loading the software from the Panel mount industrial PC workstations, repairs, extensions and modifications to trunk lines. And configure into maintenance management system and Asset management system.

6.5 Adjustments

The zero and span of the transmitters shall be adjusted through the Hand Held Communicator (HHC). A facility for engineering unit selection shall also be available from the HHC. The zero and span adjustments shall be non interactive and continuously adjustable.

6.6 Indication

Transmitters shall be complete with an integral digital output meter with 4 digits, LCD readout via. field bus communication. The output meter scale shall cover the entire transmitter range of the transmitter in Engineering Units, as indicated in the related Data Sheets for Temperature Elements and Transmitters. In addition to the above, the digital output meter shall be provided with the facility of displaying the measured value as a percentage of the calibrated span.

The temperature transmitters shall be installed such that they are readable and accessible from ground level, ladders or platforms.

6.7 Performance

The transmitter accuracy, including the combined effect of linearity, hysterisis and repeatability shall be equal to or better than as stated in the related Data Sheets for Temperature Elements and Transmitters. With reference to IEC 60770, errors shall be expressed as percentage of calibrated span, unless stated otherwise.

6.8 TemperatureCompensation

The transmitter electronics shall include for the temperature compensation. The sensor characterisation curve shall be stored in EPROM.

6.9 TransmitterHousing

The transmitter electronics shall be field-mounted type. The transmitter enclosure shall be SS316L, certified for the hazardous area classification(Diesel service) as stated in the related Data Sheet and shall be minimum weather proof to IP 68 as a minimum.

No Aluminium in its un-anodised form shall be used. No copper or its alloys shall be used.

The units shall be supplied in housings suitable for environmental condition as specified in the above Section 4.

6.10 CableEntry/Connection

The electrical signal cable entry shall be M20 x 1.5 ISO threaded. Unused cable entries shall be plugged (SS316L Plug) off in compliance with the specified electrical safety.

Signal wiring terminals shall be of the screw type. All terminals for electrical connections shall be clearly numbered. The terminals polarity, where applicable, shall be permanently marked. During coupling and up coupling the transmitter, the other instruments on the bus network communication should not affect.

NOTE: Transmitters with flying leads are not acceptable.

6.11 Installation Notes

6.11.1 General

Two types of temperature measurement shall be used for this project:

- In-line temperature measurement
- Surface temperature measurement

6.11.2 In-line Temperature Measurement

In-line temperature measurement shall be used for pipelines applications, the temperature elements shall be installed inside thermowells or protective tubes in accordance with the related Data Sheets.

The thermowell shall be installed perpendicular to the pipe wall and shall have a minimum immersion length of 2” and a maximum distance of 5” from the pipe wall as per the wake frequency calculation.

Thermowell shall not be installed in line sizes less than 4”. In smaller lines where

temperature measurement is required, the line shall be swaged up to 4" or, for 3" lines and above the thermowell shall be mounted in an elbow.

The protection tube shall be installed on the tank roof parallel with tank wall and shall have the immersion length as specified in the related Data Sheet.

6.11.2.1 Thermowell/ProtectionTube

Thermowell / Protection Tube shall be specified for all temperature-detecting elements, allowing the element to be removed during plant operations.

1½" RF ANSI flanged thermowell / 2" RF ANSI flanged protection tube for NACE service (NACE MR 01-75) shall be used for all normal duties on pipe / tank work unless otherwise stated.

Thermowell / protection tube material shall be 316SS or alternative materials to suit the process conditions.

Thermowells / protection tube shall be solid drilled and tapered, and the flange shall be attached by welding. Where welding is carried out, the welding procedure and the welder or welding operator shall be qualified as per ANSI B 31.3 provisions.

The insertion length of the thermowell / protection tube (U length) shall be as specified in the related Data Sheet for Temperature Elements and shall be stamped clearly on the flange at any visible location.

All welds subject to line pressure shall comply with the requirements of the ASME Boiler and Pressure Vessel Code, Sections VIII and IX.

The surface of the well shall be smooth and free from burrs and notches. The transition at diameter changes and connection to the flange shall be a smooth radius to minimise stress amplification.

Flange ratings shall be 300 lbs. minimum or a higher rating to suit the relevant piping specification. The flange face type and finish shall be in accordance with the relevant piping specification.

6.11.3 Surface (Skin) motor winding Temperature Measurement

Surface temperature measurement shall be used for D.G sets.

The sensor shall be duplex RTD and hardwired to the temperature transmitter.

The spring loaded sensor shall be completely encased for maximum heat transfer to the probe. The spring shall have a sufficient length to provide the necessary pressure to securely hold the sensor probe against the surface.

The mounting device clamp material shall be minimum stainless steel or as it is specified in the related Data Sheets.

6.12 Tagging

Transmitters shall be provided with an identification plate, with all data clearly stamped on a corrosion resistant plate permanently attached to each instrument by means of rivets or pins and shall indicate, as a minimum, the following:

- Name of the MANUFACTURER or Trade Mark
- Instrument Tag Number
- Serial Number
- Year of Manufacture
- Range & Calibration (including units of measurement)
- Type of Input
- Electrical safety (type of protection)
- Output Signal

Additionally, for thermowell / protection tube the following information is required to be stamped on the flange rim or lagging extension:

- Instrument Nag Number
- Temperature Range
- Flange Rating and Size
- Test Pressure
- Material

6.13 Painting

Where applicable, painting shall as per MANUFACTURER own standard, with MEW's approval.

6.14 DatasheetsforTemperaturetransmitter.Sensorandthermo-wells.

The Temperature transmitter shall comply the following spec. as a min requirements.

Data sheets for Temperature transmitter:- TRANSMITTER:-

Signal output	Accuracy	Local Display	Over Range Protection	Housing material	Mounting accessoriess	Enclosure Cert./IP	Certificate	Sunshade
4-20mA, Hart protocol, 2 wire system	+/- 0.03%	LCD Buitin configgurable	130% FSD	SS316L - Enclosure	Remote mount on 2'' Pipe with SS316L, bracket & accessories	Zone-2, Gr. IIB,T3 & IP67	Calibration, Material test certificates	SS 316L

ELEMENT:-- (including for Pump and Motor bearing and winding)

Element	Accuracy	ELEMENT SHEATH & INSULATION	CONNECTION TYPE	CONNECTION HEAD	Enclosure Cert./IP	Certificate
DUPLEX 3-WIRE PT 100 RTD, Spring Loaded.	+/- 0.075%	316SS / Mineral Insulated	NIPPLE - UNION - NIPPLE	Suitable for Remote mount tertransmit	Zone-2, Gr. IIB,T3 & IP67	Calibration , Material test certificates

Thermo well:--

Thermowell Construction /Type	Pipe line Size	Material	Process Connection	Stem Connection	Certificate	Immersion Length
Solid Bar Stock /Tapered	As per P&I'd	316SS L with NACE	Flanged OR 1'' NPT (F) as per design	½'' NPT (F)	Material test certificates, NACE compliance	As Per W.F.C Note: 2

1) Instrument data sheets to be prepared as per ISA–20–1981 STANDARD (ISA Forms S20.20a and 20.20b and Instructions for ISA Forms S20.40a and 20.40b), and submitted to MEW approval, before procurement of materials. 2) All wetted parts Material shall be minimum SS 316L and brackish water service to be monel.

2) The material shall comply with NACE MR 01-75 latest edition.

3) Thermowells:-ISA Forms S20.12a and 20.12b, ANSI MC96.1, American National Standard for Temperature Measurement Thermocouples.

4) Thermowells shall be subject to stress and wake frequency calculation by Vendor in accordance with ASME Performance Test Code 19.3

5) Resistance temperature sensors:-ISA Forms S20.13a and 20.13b, Refer to Scientific Apparatus Manufacturers Association (SAMA) Tentative Standard on Resistance, RC 5-10-1955.

6) RTD characteristic shall comply with IEC 60751 (BS 1904). The RTD shall be three wire types and shall have a resistance of 100 ohms at 0oC.

7) RTD shall be as per DIN 43760, IEC 751 class B.

8) The field instrumentation for diesel service to be complied as specified in the particular spec..

9) All instruments and equipment, which is direct contract with drinking and portable water, should have ANSI/NSF 61 standard or certified by a well- known library approved by ANSI or ANSI themselves.

7 DOCUMENTATION

The MANUFACTURER Serial Number shall provide a cross-reference to all required documentation in accordance with standard EN 10204-3.1.B.

The documentation requirement shall be minimum as follows:

7.1 7.2 DocumentationRequiredforApproval

- Full technical literature for the equipment offered.
- An unqualified statement of compliance with the specification and data

sheet requirements.

- A list of all accessory items together with MANUFACTURER's name and part number.
- The VENDOR shall provide a completed copy of the instrumentation data sheets with all changes entered.
- The VENDOR shall provide a completed SPIR form as per Attachment, for Spare Parts and Maintenance Data.
- General Arrangement / Construction Drawings
- Overall dimensions of equipment
- Design Calculations
- Calibration Certificates
- Material and Electrical Certificates / Statutory Approval by an authorized Agency
- Complete Test and Inspection Plan
- NDT Certificates (minimum dye penetration test of all welds)
- Weld Procedures and Qualifications
- Pressure Test certificates.

8 INSPECTION AND TESTING

8.1 General

The MANUFACTURER shall meet the inspection and testing requirements of BP RP 32-1. The Inspection / Testing requirement of Transmitters shall be as listed in the following sections. All required inspection and testing works should be carried out at MANUFACTURER's work prior to shipment.

8.2 FactoryTesting

Each transmitter shall be tested with the specified sensor over the range of measurement specified in the related Data Sheets for Temperature Element and Transmitters.

Each thermowell / protection tube shall be hydrostatically pressure tested at minimum 1.5 times the maximum rating.

8.3 FactoryInspection

If specified in the Purchase Order the transmitters shall be inspected by the MEW's designated inspector before dispatch unless otherwise specified.

Inspection by the MEW's inspector shall be restricted to the following:

- Visual examination and dimensional check of the process connection
- Verification of testing as mentioned under factory testing
- Verification of material certificates
- Verification of "Type of protection" certificate or declaration
- Verification of NACE MR 01-75 compliance.

9 CERTIFICATION

The MANUFACTURER shall submit the certificates in accordance with EN10204 3.1.

A material test certificate shall be provided and shall be incorporated into a works certificate as described below:

- The VENDOR shall supply a works certificate issued and signed by the MANUFACTURER's inspection, laboratory personnel, or other appropriate responsible employee. The inspection or other employee signing the certificate must be independent of the MANUFACTURER's production department.
- The works certificate shall contain numerical results of chemical, electrical and mechanical tests. The type and extent tests shall be as described by the specification for the particular material involved.
- In addition, the certificate shall include all information regarding customer, number of order, works number, type and quantity of materials. The production, process heat treatment, and other relevant features, if not limited or prescribed by the material specification shall also be included.

The test certificate shall confirm that satisfactory testing has been carried out. Manufacture's serial number shall be quoted on all certificates. The certificates shall indicate the method of marking and the material shall be marked in such a manner that it can be traced back to the certificate and test relevant to it.

All non-destructive testing shall be fully certified.

Functional test certificates shall be provided in accordance with the requirements of the above Section 8.

10 SPAREPARTS

The MANUFACTURER shall provide the recommend spare parts on the following basis:

- Commissioning spares
- Two (2) years operation spares

Parts data shall be listed on proper form and be supplemented with appropriate drawings / bulletins identifying all parts in their respective position.
The commissioning and operations spares to be handed over to MEW store.
Parts data shall be listed on proper form and be supplemented with appropriate drawings / bulletins identifying all parts in their respective position".

MANUFACTURER shall provide the Standard Recommended Spare Parts list (for maintenance) form.

The spare parts as specified in the BOQ Should not used for the commissioning and two years operations.

11 PREPARATIONFORSHIPMENT

VENDOR shall be responsible for the design, supply, assembly and application of all preservation & packaging required for safe transportation, handling and storage of Temperature Elements and Temperature Transmitters, supplied under this order, to the final destination in Kuwait.

All openings shall be sealed and threaded connections shall be protected with moulded plastic screwed plugs or caps. The Temperature Elements and Temperature Transmitters shall be packed in cartons or crates, suitable for sea shipment in such a way that corrosion and damage to parts and paint is avoided.

Each individual carton or box shall be marked with the Project Name & Code,

Purchase Order No., Tag No. and MEW's Name and Address, on the top and side of the carton / crate.

Initial spares shall be packed separately from the main equipment. The box or case shall be clearly marked 'Initial Spares', Project Name & Code, Purchase Order No. and Tag no. on the top and side of the carton. Furthermore each spare part shall have its part number clearly identified and attached.

VENDOR shall be entirely responsible for any claim arising, which is attributable to defective and / or insufficient packing.

Government of State of Kuwait

Ministry of Electricity and Water

Section:- 4C.13.

Technical Specification of Motor Operated Valves-Electrical Actuators

Contents Summary

1.0 INRODUCTION

This Specification defines the minimum requirements for the design, manufacture, supply, retrofit/modify, install, test and commission of Electrical Actuators on the new and existing valves to be used for above the project.

The scope includes to replace the existing actuators with new latest technology suitable for the new DCS system.

2.0 REFERENCE DOCUMENTS

Reference has been made, in this specification, to the latest edition of the following Codes, Standards, and Specifications:

Codes and Standards

API STD. 6D	-	Specification for Pipeline Valves
API 598	-	Valve Inspection and testing
API STD. 6FA	-	Fire Test for Valves
API 607	-	Fire Test for Soft Seated Quarter Turn Valves. ASME
B16.5	-	Steel Pipe Flanges and Flange Fittings
ASME B16.34	-	Steel Valves
ASME Sec. IX	-	Boiler and Pressure Vessel Code – Welding and Brazing Qualification
BS EN 10204	-	Metallic Products – Types of Inspection Documents
BS EN 10204	-	Metallic Products – Types of Inspection Documents
BS 2757	-	Method for Determining the Thermal Classification of Electrical Insulation
BS 4999 Part 111	-	General Requirements for Rotating Electrical Machines. Specification for Built-in Thermal Protection for Electric Motors rated for 660 volts A. C. and below.
BS 4999 Part 143	-	General Requirements for Rotating Electrical Machines. Specification for Tests.
BS EN 60034 Part 1	-	Rotating Electrical Machines – Rating and Performance.

IEC 60529 - Degrees of Protection provided by Enclosures (IP Code)

ISO 5210 - Industrial Valves: Multi-turn Valve Actuator Attachment.

ISO 5211 - Industrial Valves: Part-turn Valve Actuator Attachment.

ISO 9001 - Quality Systems – Model for Quality Assurance in Design, Development, Production, Installation and Service

NACE MR 01-75 - Sulphide Stress Cracking Resistant Metallic Materials

3.0 Project Specifications and drawings:-

a. Particular Spec -

4.0 Order of Precedence:-

In case of conflict between the requirements of this specification and the referenced codes, standards, and specifications, the following precedence shall apply:

1. This Specification.
2. Project Specifications.
3. Other International Codes and Standards.

5.0 ENVIRONMENTAL CONDITIONS:-

The environmental of Kuwait, is severe on all equipment and must be considered carefully before design and procurement of plant and equipment. It must be assumed that, unless of otherwise specified, equipment may be subjected to sand and fine particle dust storms, sand laden winds, chemical contaminants, thunderstorms, heavy rain and extreme temperatures.

TEMPERATURE AND HUMIDITY

Summer maximum dry bulb temperature : 65°C, shade

Summer minimum wet bulb temperature : 28°C

Summer maximum average dry bulb temperature : 50°C

Summer maximum dry bulb temperature (Solar): 80°C

Soil temperature at 1.22m depth: maximum 35°C. minimum 17°C.

For electrical equipment design, ambient temperature shall be –3°C to 65°C for all indoor and outdoor equipment shall be –3°C to 75°C for the electrical actuators and with all its accessories.

Except for as limited by coating on pipes, the surface design temperature (applicable) shall be 93°C for equipment and installation.

a) Direct Sunlight : Exposed metal black body maximum temperature due to solar radiation : 85°C

b) Shade Temperature : 65°C maximum

45°C average (1day)

–3°C minimum @ 100% RH

Note:- All equipment and materials shall be suitable for this direct sunlight temperature unless installed in a protected environment. Sunshades shall be provided where appropriate.

c) Exposed white body maximum temperature : 63°C

d) Winter minimum dry bulb temperature : –3°C

e) Winter minimum average dry bulb temperature : 7°C

f) Winter minimum average wet bulb temperature : 3°C

Note:- These dry and wet bulb temperatures shall be used for winter heating design purposes.

g) Relative humidity maximum at:55°C, 50% at 0°C, 100% varying from 6 to 100%

5.1 Atmospheric Conditions:-

The atmosphere is generally dusty and corrosive and in some areas may contain traces of hydrogen sulphide.

SAND STORMS

Kuwait is subject to sandstorms, particularly during the summer months:

a) Ambient air range minus –3°C to 55°C

b) 16 grams dust per 100 cubic foot air.

c) DustParticleSize (micron) — Wt%FineDust (Plus/minus 3%)

0-5	39
5-10	18
10-20	16
20-40	18
40-80	9

WindData

a) Maximum recorded wind speed : 38 m/s

b) Design maximum wind speed : 45 m/s

c) Summary prevailing wind direction / speed : SE, 6 m/s (Burgan area)

d) Winter prevailing wind direction / speed : NW, 6 m/s (Burgan area)

e) Prevailing wind direction / speed : NNW, 6 m/s (North Kuwait)

f) Summer prevailing wind direction : NNW (North Kuwait)

g) Winter prevailing wind direction : SSE (North Kuwait)

Rainfall

Kuwait is subject to thunderstorms and heavy rainfall.

a) Annual maximum : 200 mm.

b) 115 mm/h, falling uniformly for 30 minutes

SeismicData

Kuwait is not subject to earthquakes, and is therefore not an active seismic zone.

6.0 QualityAssurance:-

The MANUFACTURER shall operate a Quality System meeting the requirements of the relevant Part of ISO 9000.

The MANUFACTURER shall ensure that his sub-suppliers operate a quality system meeting the specified conformance criteria to ISO 9000. The MANUFACTURER's quality system shall be subject to the MEW's approval prior to commitment to a Purchase Order.

Major sub-suppliers shall be subject to identical approvals. The MEW reserves

the right to conduct a Quality Audit at the MANUFACTURER's/sub-supplier's facilities at any stage during manufacture.

7.0 DESIGN AND FABRICATION

7.1 VALVE:-

The Motor Operated Valve shall be Butterfly Isolation Valves and Flow control valve as specified in the Process flow diagrams and piping general arrangements drawings. The valve shall be designed in accordance with MEW Mechanical Specification and shall be suitable for the service conditions as indicated in spec and std. The valve actuator shall comply in the related Motor Operated Valve Data Sheet.

All Design, Material, Fabrication, Inspection and testing of Valve shall be as per MEW standard.

7.2 MOTORIZED VALVE ACTUATORS.

Design andConstructionRequirements:-

3.9.1 General:-

The submersible, water resistant actuator to be provided by Contractor and the same shall be placed inside the valve chamber.

The valve actuator details, catalogues, etc., shall be submitted to the Engineer for approval prior to ordering.

Weather Proof Safety Switch (power isolation switches details are mention on the Electrical section) shall be provided for power circuit cut-out. The actuator shall be sized to guarantee the valve operation closure at the specified differential pressure at least 16Kg/Sq. cm. the safety margin available for seating and unseating the valve shall be sufficient to ensure torque switch trip at maximum value torque with the supply voltage 10% below nominal. The closing and opening time shall be suitable for the operation of the system.

The actuator shall be capable of functioning at ambient temperature range for -3°c to +75°C. The enclosure shall be double - ring sealed water tight to IP68. The electrical accessories shall be housed inside a separate compartment easily accessible for maintenance.

The electric motor shall be 3 phase 415V, 50Hz Class H insulated with a time rating of

twice the valve stroking time (maximum of 30 minutes) at an average load of at least 130% maximum valve torque.

Overload protection shall be provided by direct sensing of motor temperature by a thermostat embedded in the motor winding.

A hand wheel with proper maintenance access shall be provided for emergency operation engaged when motor is declutched by a lever or similar means, the drive being restored to power automatically by starting the motor. Hand wheel drive shall be mechanically independent of the motor.

Phase sequence and failure relay shall be employed for protection against any phase reversal or failure.

Actuators shall be designed for valve operation to ensure proper function. Actuators shall be rated for the following duty classifications according to IEC 34 / VDE 0530 depending on application or equivalent:

a) Short-time duty (2-10min) for OPEN/CLOSE operation

b) Intermittent duty (4-25% END DRIVE); up to 600 starts per hour; no. of starts depending on actuator size and output speed for MODULATING operation.

All actuators must be suitable for operating in any mounting position and easy to rotate 360deg. position.

The actuator's shall provide an Bluetooth Connectivity, exchange the data communicate via. wireless communication path to exchange the data to the portable communication device and exchange the data as a minimum distance of 50 mtrs, in the industrial environmental

The Manufacture shall provide one no. of battery backed setting tools (windows based operated I Pad portable device) with latest model /configuration and loaded software, including windows, actuators logics, up load & down load the software, monitor /control functions, view data logger information, fault diagnostics & investigations, asset management, etc…

In addition to the Settings tools, the actuators shall have built-in push buttons for monitor and control functions.

To guarantee proper function under high ambient temperatures, torque and limit sensing shall be of the mechanical type. All materials used shall be suitable to withstand operation under specified environmental conditions. All necessary precautions shall be taken to avoid any type of corrosion and electrochemical effects, which may take place

between different kinds of metals.

For rising stem applications, the design must allow removal of the actuator from the output drive without disturbing the function of the valve.

The actuator shall be suitable to install on the existing raising / non-raising stem manual gate/sluice valve.

The actuator shall be suitable to install on the existing manual butterfly valve.

Torque-transmitting housings must be made of cast iron, with the exception of the motor housing.

In order to minimize the amount of spare parts required, parts such as covers, plug / sockets etc. must be interchangeable throughout the model sizes installed.

Actuators shall be designed in such a way, that exposure to the environment will not interfere with the safe operation. All joints shall be sealed by radial seals or O-rings.

In order to prevent loss of screws during commissioning or maintenance, all covers shall be fixed with captive screws.

Depending on valve application, actuators shall be self-locking. Self-locking shall remain active even if the actuator is switched into hand-operation-mode.

Valve mounting dimensions shall be according to ISO 5210 or ISO 5211 for multi-turn or part- turn applications respectively and refer to the valve specification.

3.9.2 **Electric motors**

General

All motors shall be specifically designed for valve-actuator operation which is characterized by high starting torque, low stall torque and low inertia.

Motors shall be of the non ventilated totally enclosed type (TENV). Motor housings and covers to be made of sea water resistant aluminium.

Motor-insulation must be in accordance with IEC 85 Class H

Motors must be protected by thermal contacts, which are embedded in the motor windings. Motor connections shall be internal by means of a plug and socket.

Motors must be totally separated from the lubricant-filled gearing of the actuator, allowing

replacement of motor without losing any lubricant, regardless of mounting position.

Actuator motors must develop full torque when power is turned on. All motors shall be of the high starting torque type to facilitate 'unseating' of the valve. Each motor shall have a rating plate marked in accordance with IEC 34.1 as far as applicable.

MOTOR	Type	Asynchronous Squirrel Cage, 3 Phase
	Rating	Vendor kW
	Full Load Current & Power Factor	# A, # pF
	Starting Current & Power Factor	# A, # pF
	Nos. of consecutive Operation	12 Nos.
	Continuous Operating Time	30 Minutes
	Speed	# (rpm)
	Insulation Class (winding)	H
	Temperature Rise Class	B
	15 Min. Temperature Rise Limit	#
PROTECTION	Overload	Required
	Single Phasing	Required
	Earth Fault	Required
	Stalling Locked Rotor	Required
	Auto Phase Correction	Required

Sizing:-

One actuator size (same outside dimensions) shall be available to cover various output speeds for a given torque range, to avoid over sizing and unnecessary weight load on valve stem, flange and yoke.

Actuators must be selected to provide sufficient torque required for safe valve operation. The actuator output torque must be available at 90 % of the nominal voltage.

In order to enable proper sizing of applicable electric equipment, the actuator supplier has to disclose the current value at maximum setting torque. The actuator shall be capable of opening and closing the valve against full differential pressure within the time specified on the valve data sheet.

Limit and Torque Monitoring

Torque and limit switching setting devices must be easily accessible for adjustment.

Torque and limit switching may be of the mechanical type and allow settings with infrared

led hand setting tools as requiring special tools or instruments.

Unless otherwise specified, electric valve actuators shall be equipped with two limit switches, one for the end position 'OPEN' and one for the end position 'CLOSED'.

For torque seating and over-torque protection, actuators must be equipped with two torque switches, one for opening and one for closing direction.

All switches (limit and torque) shall be of the snap-action type, totally enclosed to a minimum of IP68. Each switch shall have two sets of NO and NC contacts. Switches with change-over functions (single break) are also acceptable. The connecting wires shall be sealed in the switch enclosures.

Torque and travel limitation to be adjustable as follows:

Position setting range 1 to 500 or 10 to 5000 turns

The torque sensing shall be of the mechanical sliding worm principle with torque values independently settable for 'OPEN' and 'CLOSE' direction. No electronic torque sensing derived from motor current or similar or piezo electric torque sensing at the worm shaft shall be used.

The torque sensing shall also be operable in non-electrical operation.

Torque setting: 40% to 100% of rated torque.

Torque delivered to the output between the end positions shall be 50% of the nominal torque.

Where valves are provided with electrically operated actuators, the actuators and valves shall be provided as complete tested units.

All valve actuators shall be provided with the necessary equipment, cables and connections to provide all necessary control actions and status indications to the local and station control systems.

The rating of all volt-free contacts shall be 5A, 250V ac 30V dc. Volt-free contacts shall be gold flashed contacts unless otherwise specified.

An alternative system for manual hand wheel operation requiring a force at the rim of the hand wheel of not more than 350N.

Phase discriminator for single phase and phase reversal protection.
Thermal overload protection.

Local/Off/Remote lockable rotary selector switch.
Local "Open", "Stop" and "Close" controls.
Local indication of valve position.

Three volt free contacts at each end of travel for remote indication, one contact normally closed two contacts normally open at each end of travel.

Torque switch for mechanical overload protection on closing. One volt-free normally open contact for remote trip indication.

Monitoring relay, de-energised when any one of the following conditions exists:

Power supply to actuator failed
Control power supply failed
Local stop pushbutton not reset
Local/off/remote switch not in remote position
Motor tripped on overload

The monitoring relay contact shall be closed when the relay is energised and the local/off/remote selector switch is in the remote position to initiate a 'remote control available' indication.

Actuators shall be provided with the following valve control and status signals.

Control
- open valve
- Close valve
- stop valve

Status
- actuator available for control
- Valve fully closed
- Valve fully open
- Actuator travelling (where specified)
- Valve position (analogue 4-20mA where specified)
- End position reached
- Intermediate position reached.
- Faults (collective fault signal)
- Running indication
- Motor protection tripped
- Preset torque exceeded
- Selector switch position (LOCAL or REMOTE)
- Loss of phase
- Position indication
- Torque indication

Data interfaces for diagnosis and maintenance:

Data interfaces for diagnosis and maintenance:

- The electrical actuated valves shall provide redundant Profibus Dp output module to communicate via. Two wire system (1px1.5sq.mm cable) in fault tolerant ring network to the Redundant Profibus Dp module and integrate /configure into redundant DCS controller, as shown on the cable interconnection drawings for all the sites such as E14,E15,D14,D16 stn.

- The actuator shall special type plug-in adaptor for easy maintenance.

- Access to the electronic name plate of the actuator (via redundant Profibus DP communication)

- The actuator controls shall have an additional inputs for connecting the non-field bus compatible instruments. The inputs, if required, shall be a minimum of 2 analogue inputs (0/4…20 mA) and 4 digital inputs (24 VDC).

  - The Power supply to the non-field bus instruments shall feed from internal (built- in) actuators and external power supply (24vdc) to be provided, in case of actuators power fails.

  - External 24v DC power supply to be provided in each actuator E/O convertor, incase Power supply to the actuator fails the fibre optic communication to the other actuator should not affect.

  - Local controls:- Local controls with push button type control, selector switch, LCD display and motor controls (reversing contactors) shall be available. The local controls shall be electrically attached to the actuator via a plug and socket connection. It shall be possible to re-position the local controls by 4 x 90°, so that the push buttons and indication lights are easily accessible and readable to the operator.

  - In inaccessible areas or locations subject to high levels of vibration it shall be possible to separate, at any time, the local / motor controls

    (including motor controls) from the actuator. A wall bracket shall be available as an option to mount the local controls / motor controls near the valve actuator.

- All control signals, communication signals as well as the mains power supply shall be wired to a multi pin plug and socket for customer connection.
- The termination inside the actuator to be as per manufacturer std and should be easy for operate and maintenance.

1. The operator face plate shall include:
2. Four push-buttons for OPEN - STOP – CLOSE – RESET.
3. Backlit LCD display with 4X20 characters, showing the actuator status in self-explanatory plain text.
4. Lockable selector switch with LOCAL - OFF - REMOTE function.
5. Five indication lights, one in colour yellow for CLOSED, three in colour red for OVER TORQUE direction OPEN, MOTOR OVER TEMPERATURE, OVER TORQUE direction CLOSE and one in colour green for OPEN.
6. Running or travelling indication: blinking indication lights OPEN/ CLOSE.
7. Motor controls:- The following features shall be in the integral motor controls:
   - Reversing contactors (mechanically and electrically interlocked).
   - Programmable control logic in CMOS SMD-technology, microprocessor based.
8. Electronic timer for the prevention of water hammer: Start and end of stepping mode as well as ON and OFF time shall be programmable individually for the directions OPEN and CLOSE. The timer shall be active in both LOCAL and REMOTE control modes
9. Illuminated LC display, 4 lines with 20 characters each plain text display, and 5 indications lights (programmable).
13. Switch able termination resistances shall be available in each and every actuator in order to facilitate the active bus termination at the last actuator in the network.
14. Retrievable and re-settable data log for motor run time, total number of cycles, number of torque trips in each direction of travel, number of limit switch trips at each end of travel, total torque trip faults and motor thermal overloads.

16. Diagnostic capability, which will store historical actuator operation data to permit analysis of actuator and valve in-service performance. Data download shall be carried out without removing any covers and all shall be available locally to the actuator or remotely via laptop computer via a two way information infrared interface.

17. Wiring and terminal boxes
All control signals, communication signals as well as the main power supply must be wired to actuator multi pin plug and socket.

The terminal compartment shall provide sufficient space to accommodate the possible maximum number of incoming and outgoing cables as per manufacturer recommendations. Each cable entry shall be properly sealed by (SS316L with IP68) cable glands during site installation. The cable glands size shall be chosen by the contractor, responsible for wiring during the commissioning phase. The actuator shall provide an adequately sized internal and external connection for Earthing. All spare cable entry to be sealed or pulsed by the SS316L thread plug

18. Hand wheel

Actuators must be equipped with a hand wheel for manual operation. Clockwise operation of the hand wheel shall cause clockwise movement of the output drive. The face of the hand wheel shall be clearly marked with an arrow and the word
'CLOSE'.

The hand wheel must be sized in such a way, to allow easy manual operation of the output drive.

Operation of the hand wheel shall require manual declutching. Under manual operation, the hand wheel shall drive the worm shaft. Self-locking shall be maintained in hand operation. The motor must be disengaged during manual operation. The hand wheel shall automatically disengage when the electric motor is energised.

19. Bearings and gears

Bearings shall be of the anti-friction or self-lubricating type. Bearings shall not require any maintenance between general overhauls.

Power gears shall be made from heat treated steel. Worm-wheels shall be made of

bronze material.

The actuator gear housing shall be filled with an adequate quantity of lubricant. Re- lubrication between general overhauls shall not be required.

Noise level

Under all operating conditions the noise level of actuators shall not exceed 75dB(A)at 1

m. Name plates

Two nameplates, made of stainless steel, shall be attached to each actuator; one on the motor housing, showing all relevant motor data, one on the actuator housing showing all relevant actuator data. Special information, such as the valve tag no. service, location, etc… shall be shown.

The nameplates shall be securely fixed to the actuator and motor, so that they cannot be removed or scratched off during shipment, installation, operation or maintenance.

Painting and corrosion protection

Corrosion protection shall fulfil the requirements of salt spray tests in accordance with DIN 50021.

Actuator painting must be performed in such a way, that no corrosion takes place under the ambient conditions as specified. All outside screws or bolts shall be made of stainless steel (A2).

Surface preparation for cast iron parts shall be sand blasted, equivalent to Sa 2 ½ according to SIS 0559 000-1967 / DIN 55 928, part 4.

Surface treatment for external parts which need to be removed during commissioning or maintenance shall be electro dip coated or metallic surface protected.

Primer coating: 2-component primer based on epoxy resin with micaceous iron oxide

Finish coating:
Structure: 2-component coating based on polyurethane micaceous iron oxide

Colour: silver grey (DB 701, similar to RAL 9007) Entire film thickness: at least 200 µm

INSPECTION AND TESTING AT MANUFACTURERS WORK

Each actuator shall be factory tested along with valve and witnesses by the third party inspector appoint by the contractor. The tests shall be performed in accordance with IEC standards as far as applicable.

The FAT should be done as a integrated test along with valve and signed by the TPI and submitted to MEW, before shipment.

A final inspection record shall be supplied with each actuator. This shall include the following information:

- General actuator data
- Nominal current o No load current o Starting current
- Power factor at rated torque
- Output speed
- Torque switch setting
- Limit switch setting (turns/stroke)
- High voltage test
- Functional test (including all options)
- Visual test

8 DOCUMENTATION

The documentation requirement shall be as listed below. MANUFACTURER Serial Number shall provide a cross-reference to all required documentation in accordance with standard EN 10204-3.1

a DOCUMENTATION REQUIRED FOR APPROVAL

- Full technical literature for the equipment offered.
- An unqualified statement of compliance with the specification and data sheet requirements.
- A list of all accessory items together with Manufacturer's name and part number.
- The VENDOR shall provide a completed copy of the Valve Data Sheets with all changes entered.

- ISA data sheet
- Assembly drawings with overall dimensions, including the Valve, Actuator and all accessories and features. Complete dimensional details of the support foot (where applicable) shall be indicated in these drawings.
- Detailed sectional drawings showing all parts with reference numbers and materials specification.
- Wiring Diagram.
- Catalogue, manuals for various items.
- Design Calculations.
- Welding, Heat Treatment, Inspection and Testing Procedure.
- Details of the proposed painting system.
- Quality Control Manual, Quality Control Plan and required Quality Procedures.

Manufacture shall commence only after approval of the above documents. Once approval has been given by the MEW, any changes in design, material or method of manufacture shall be notified in writing to the MEW. MEW approval shall be obtained for all changes before the valve is manufactured

On receipt of written approval, the MANUFACTURER shall submit to the MEW all approved documents as listed above.

Prior to shipment, the MANUFACTURER shall submit the test certificates to MEW for approval.

Documents shall be in the English Language.

9 INSPECTION AND TESTS

The MANUFACTURER shall meet the inspection and testing requirements as mentioned in this document and Standard for Motor Operated Valve Actuator. All required inspection and testing works shall be carried out at Manufacturer's work prior to shipment

The MANUFACTURER shall appoint a reputable Third Party Inspection Agency (i.e. BVQI, Lloyds or DNV), to carry out all inspection and tests as per the requirements of this specification and the relevant codes and standards, at his works prior to shipment. The Third Party Inspection Agency shall be approved by the MEW prior to his appointment.

The inspection and tests shall be as a minimum, but not be limited to, the following:

- Visual inspection for compliance with Order Specification and Workmanship.

- Dimensional checks on all valves and actuator shall be carried out as per the drawings approved by the MEW.
- Review Manufacturer's Material and Test certificates for all items. Ensure that certificates are related to material by Heat or Serial Numbers. Review Manufacturer's test certificate for all bought out items.
- Witness Hydrostatic/Pneumatic Tests.
- Witness performance test for Actuators on assembled Valves.

A final inspection record shall be supplied with each actuator. This shall include the following information:

- General actuator data
- Nominal current
- No load current
- Starting current
- Power factor at rated torque
- Output speed
- Torque switch setting
- Limit switch setting (turns/stroke)
- High voltage test
- Functional test (including all options)
- Visual test

The MEW reserves the right to perform stage-wise inspection and witness tests at the Manufacturer's Works prior to shipment. The MANUFACTURER shall give reasonable access and facilities required for inspection to the TPI Inspector.

The MEW reserves the right to require additional testing, at any time, to confirm or further investigate a suspected fault. The cost incurred shall be to the Manufacturer's account.

In no case shall any action of the MEW or his Inspector relieve the MANUFACTURER of his responsibility for material, design, quality or operation of Valves. Inspection and tests performed/witnessed by the MEW's Inspector shall in no way relieve the Manufacturer's obligation to perform the required inspection and tests.

10 TEST CERTIFICATES

The MANUFACTURER shall submit the following certificates in accordance with EN 10204 3.2 for the Valves, 3.1 for the Actuators:

- Mill test certificates relevant to the chemical analysis and mechanical properties of the materials used for the valve construction as per the relevant standards.
- Report on heat treatment carried out.
- Test certificates of hydrostatic and pneumatic tests complete with duration and pressure records of each test.
- Test reports of radiography, ultrasonic, MPI and DP inspection.
- Fire Safe type test certificates, as appropriate.
- Test report on operation of valves.
- Integrated Functional test.

The certificates shall be valid only when signed by the MEW's Inspector. Only those valves which have been certified by the MEW's Inspector shall be dispatched from the Manufacturer's works.

11 SPARE PARTS:-

The Manufactures shall provide the recommend spare parts on the following basis:

- Commissioning spares
- Two (2) years operation spares

All the spare parts to be tested and certified by MEW at Site, before handing over to MEW store.

The commissioning and operations spares to be handed over to MEW store.

Parts data shall be listed on proper form and be supplemented with appropriate drawings / bulletins identifying all parts in their respective position".

MANUFACTURER shall provide the Standard Recommended Spare Parts list (for maintenance) form for Spare Parts and Maintenance Data.

The price for the spare parts shall be included in the respective item of the actuator BOQ.

Note:-

The specification for butterfly isolating valves and plunger are covered under the mechanical section, of this tender.

Government of State of Kuwait Ministry of Electricity and Water

Section4C.14

Technical Specification for Fiber Optic Cables

Technical Specification for Fiber Optic Cables

1) INTRODUCTION

MEW intends to make DCS system, video surveillance system, VoIP, Hot line telephone system for the F.W Water Distribution complex and Water treatment chemical system into the local and remote monitoring control centre. The fiber optic cable shall be used to transfer the video, data and voice to the remote control centre for monitor and control. The Plant DCS data, IP video surveillance and IP telephone system shall be transferred via. new fibre optic cable installed under this contract and existing cable.

2) PARTICULAR CONDITIONS:-

2.1) Subcontractor for Fibre optic cable;

The Contractor shall subcontract the specialist fiber optic cable telecommunication subcontractor under the above who shall perform said work for the OTDR test and Splicing of optical cable work. The Main Contractor should understand that this shall not relieve him from any responsibility under this Contract.

The review/approval of any documents or drawings from MEW shall not relieve the contractor's responsibility to meet the requirements as specified in tender specification, drawings or BOQ, even after commissioning the work, expect the Deviations approved by the MEW.

The Deviations may be considered in special circumstances, but must be clearly mentioned in a separate official letter 'Deviation Note with Proper Justification" and shall be subject to MEW Engineer approval.
The contractor shall submit the capacity evidence of the specialist fibre optic cable subcontractor describing his experience in splicing, testing of similar projects for MEW approval.

The Engineer has the right to reject the proposed specialist fibre optic subcontractor based on his insufficient qualifications or his fast experience or incompetence during contract execution, at any stage of the contract. In such case, the contractor shall propose for substitute specialist fibre optic telecommunication subcontractor, for MEW approval at his own expenses.

2.4) List of Pre-Qualified manufactures for the supply Of Cables

- Gulf Cable Company / Kuwait
- Oman Fiber Optic Company / Oman
- Middle East Fiber Cable Mfg. Co. Ltd /KSA
- El Sewedy Fiber optic Cable Company /KSA
- Belden Fiber optic cable /Gmbh

TECHNICAL SPECIFICATION FOR FIBRE OPTIC CABLES, DUCTS AND ACCESSORIESS:-

a) FIBER OPTIC CABLE SPECIFICATION

1.0 GENERAL

This Section covers the min requirements for the Supply, transport to place of work, lay, install, inspection test and commissioning of single mode fiber optic cable, double armoured anti corrugated steel tape, with triple HDPE polyethylene (UV Rated) sheath with complete all required accessories such as splicing kit, machine, OTDR test equipments, etc.. including excavate cable trench, backfilling, sleeves, PVC tiles, steel wire warning tape, tag plate, RC hand hole, R.C manhole, splicing of cables, HDPE duct under road crossing etc. as per specification and drawings.

2 Reference standards

Cable shall be provided and installed in accordance with Fibre Optic Industry Code of Practice for the installation of Fibre Optic Cabling British Standard BS7718:1994 or equal, or unless otherwise specified or approved, the telecommunications systems shall comply with the current version of the relevant Reference Standards including those listed below:-

British Standards

BS 7718	Installation of fibre optic cabling
BS9230	Specification for connectors of assessed quality for optical fibres and cables.
BS EN 50081	Electromagnetic compatibility Generic emission standard
BS EN 187000	Optic fibres
BS EN 188000	Optic fibre cables

Other Standards

ITU – T	Telecommunication Standardisation Sector of ITU (previously)
CCITT –	The International Telegraph and Consultative committee).
G.652D	Characteristics of a Single-Mode Optic Cable

3 Submissions by the contractor;

3.1 Scope of Submissions

The Contractor shall make submissions to the Engineer of all design drawings and data sheets relating to fibre optic telecommunications systems and equipment. These submissions shall include, but not limited to, the following:

3.2 Statement of Compliance.

The Contractor shall provide copies of the reference standards used and shall provide a compliance/non-compliance statement.

3.3 System Description

The Contractor shall submit a complete written system description for each telecommunications system for consent by the Engineer.

The system description(s) shall describe the "fail safe" features incorporated into the design in the event of a failure of a plant item or system, or loss of an input signal affecting a telecommunications system. The description shall also cover what happens during a power failure.

The description(s) shall be presented in a clear and precise manner and shall include figures or drawings where appropriate.

3.4 Design Documentation, Drawings and Data sheets

(a) General arrangement drawings of field-mounted fibre optic cable related telecommunications equipment showing installation details (including location drawings, mounting arrangements and housing details).

(b) General arrangement drawings fibre optic cable related telecommunication panels, fully dimensioned in plan and elevation views, showing foundation and fixing details, access doors, clearances, cable entry positions, weight and lifting arrangement.

(c) Layout drawings of panel and details of all labels.

(d) Layout drawings of panel interior showing equipment, core switches, marshalling blocks and cable ways.

(e) Internal circuit and wiring diagrams for telecommunications panels.

(f) Cable blocks diagrams.

(g) Telecommunication systems and panel power distribution diagrams.

(h) Labelling lists.

(i) Comprehensive testing schedules for all off site, on site, pre-commissioning and commissioning tests and take over tests.

(j) All other drawings necessary for the provision of ducts, openings, trenches, fixing holes for panels etc. and for the complete understanding of the operation, maintenance and extension of the system including any drawings required for the Purchaser to dismantle, repair, maintain, modify or extend the Plant.

3.5 Data and Calculations

(a) Manufacturers' catalogues and data sheets

(b) Calculations to support telecommunications system design

(c) Specification for protective coatings and painting

3.6 Certificates

(a) Manufacturers' Works tests

(b) Pre-installation checks

(d) Fibre optic telecommunications system test check sheets

(e) Installed telecommunications systems performance tests

3.7 Operation and Maintenance Instructions

(a) Composite manual describing the function and operation of each piece of equipment.

(b) Composite manual for testing and servicing every system and individual item.

4 Fibre Optic cable requirements;

4.1 General;

This covers the requirements for filled optical fibre cable to be laid along with pipeline as per contract drawings.

The optical fibres shall be single mode reduced type secondary protected by loose tubes.

The tubes shall be filled with filling compound and stranded, together with fibres, around a glass fibre reinforced plastic (FRP Rod) strength member to form a compact and circular core.

The cable structure shall be completed by application of a suitable plastic core wrapping. Over the wrapping an aramide yarn as strength member shall be applied. An UV resistant polyethylene outer jacket shall complete the cable.

The single mode OFC shall be anti corrugated steel tape armoured with HDPE polyethylene (UV resistant rated black, HDPE) sheath and suitable for outdoor direct burial cable

The cables shall be suitable for the ambient conditions specified elsewhere.

4.2 Anti corrugated steel tape armoured Optical Fibre Requirements;

The cable structure shall be completed by application of a suitable core wrapping and on APL (aluminium Polyethylene Laminate) inner sheath. Anti-rodent corrugated steel armour shall also be provided. An outer sheath in polyethylene shall ensure good protection.

4.3 Secondary Coating;

The jacket of each fibre shall be loose tube of high modules plastic, reclaimed material shall not be used.
Each loose shall have two fibre.

The typical outside and inside diameters of the loose tubes shall be 10.5mm and 1.0 mm respectively. Each loose tube shall be filled with a filling compound consisting of fumed silica dispersed in oil to prevent water ingress and to ensure low stress level of the fibre.

4.4 Strength member;

The centre of the cable core shall contain a strength member of steel with a typical diameter of 2.5mm or fibreglass reinforced plastic with a typical diameter of 3mm. The diameter shall be defined in accordance with the maximum pulling force declared.

4.5 Fibres Identification;

The secondary coating tubes of the fibres shall be coloured for counting of the fibres and counting direction identification. The fibre coating shall be in accordance with Manufacturer Standard.

4.6 Moisture Barrier Sheath;

To prevent moisture penetration the cable core shall be completely covered with a plastic coated aluminium foil, applied longitudinally with an overlap of at least 3mm. The foil shall consist of a double plated thermo-welded aluminium tape with a minimum thickness of 0.1 mm + 0.02 mm provided with a protective plastic coating. The thickness of the plastic coating shall be at least
0.003mm.

The aluminium foil shall have electrical continuity throughout the cable length in order to assure that the foil is made from a unique tape.

Outside the aluminium foil a polyethylene sheath shall be extruded.

4.7 Anti corrugated steel tape armoured Optical Fibre optic cable;

The protective covering shall be made by galvanised corrugated steel tape. The steel armour tape shall be applied longitudinally and thermo welded over the inner sheath, it shall have a nominal thickness of 0.18 mm (with a minimum of 0.14 at any point) thick with a coating (0.06 + 0.01mm) on both sides to provide corrosion resistance. The tape shall be corrugated with, at least, 12 corrugations per 25mm of cable and longitudinally applied with, at least, 3.2mm overlap.

4.8 Fibre Requirements

Each single mode optical fibre shall be designed to provide good performance at 1310 nm and/or1550nm.

Fibre material;

The fibre material shall be manufactured with pure silica cladding and doped silica core in order to guarantee optical transmission performances. The index profile shall be of matched cladding or segment core design.

Coating Material;

The primary coating shall consist of a composite layer of acrylate (UV cured). The adhesion between the primary coating and the fibre shall also be maintained in the presence of a wet environment.

Optical Characteristics;

The optical transmission characteristics shall be homogeneous without discontinuity points and the attenuation shall be verified using OTDR (Optical Time Domain Reflectometer) techniques at 1310 and 1550 nm..

Secondary Coating

Reclaimed material shall not be used.

The jacket of each two fibre shall have one loose tube of high modules plastic construction.

Each loose tube shall be filled with a filling compound consisting of fumed silica dispersed in oil to prevent water ingress and to ensure low stress level of the fibre.

Central Member

The centre of the cable core shall contain a strength member of glass fibre reinforced plastic, typically 2.5 mm in diameter min. The diameter shall be defined in accordance with the pulling force declared.

Fibres Identification

The secondary coating tubes of the fibres shall be coloured for counting of the fibres purpose and counting direction identification. The fibre coating shall be coloured in accordance to the international std. Color code IEC-304 and Manufacturer Standard.

Filling

The interstices between secondary coating, strength member and core wrapping shall be filled with filling compound to prevent axial and longitudinal flow of water. The filling compound should have the molecular hydrogen absorption property.

Core Covering

The standard core shall be covered with a synthetic tape with hydrogen absorbing filler. **Strength Layer**
A layer of aramide yarns shall be applied longitudinally on the core covering as strength element.

Outer Sheath

The outer sheath shall consist of a tough weather resistant, UV resistance polyethylene compound. The sheath shall be circular, free from pinholes, joints, repairs and other defects. The covering design shall consist of a three layer jacket. The jacket thickness shall be in the range between 85 percent and 115 percent of the specified nominal thickness or as specified above. More over the jacket thickness shall be, at least, 19% of outer diameter. The jacket eccentricity as defined below shall not exceed 40 percent.

In the design, a three layer weather resistant medium or high density polyethylene jacket shall be applied over the armour with a nominal thickness that shall be at least 13 percent of the outer sheath diameter.

Identification;

The outer sheath shall be embossed with the following inscriptions (every 10 meters): -
Manufacture name;

- Week and year of fabrication;
- Employer;
- Contract name;
- Contractors name.
- Type of Cable.
- Length (every meter)

A progressive metric marker (meters) shall also be printed onto the sheath in Arabic and English

The letters shall be clearly printed by means of non-metallic paint in Arabic and English;

Cable Length;

The cable length supplied shall be nominally 3000 m on a single reel.

The reel length shall not deviate by more than minus 0 m to plus 50 m from the nominal drum length.

Part. II Technical specification of HDPE Cable duct:-

Two numbers of 160mm dia, 6.2mm thick HDPE Cable duct shall be laid under the road crossing/pipeline crossing, not less than 2 mtr depth. The HDPE duct shall be rating of PN 6, in accordance with ISO 4427 and DIN 8074 std. spec. The cost for the item to be included in the respect item of BOQ

4.9.1 Identification

The ducts and fibre optic cable shall be embossed with the following inscriptions at intervals of at least 10 meters:

- Manufactures name,
- Standard code;
- Type of Cable running inside duct.
- Length (every meter)
- Week and year of fabrication;
- The letters shall be clearly printed by means of non-metallic paint in Arabic and English;
- Guaranteed Performance;

The Manufacturer / Contractor shall assure that the duct joints time of life shall be at least 25 years under the installation conditions.

4.9.2 Quality Assurance

The Contractor shall submit a copy of the quality certificate to ISO 9000.

4.10 Inspection and Testing

During manufacturing all the tests shall be performed by the Contractor in order to assure duct performance. The Contractor shall carry out tests on incoming goods to verify the integrity of the materials to be used for the manufacturing. All line tests shall be certified. Moreover copies of Certificate of Origin relative to primary HDPE material shall be provided. Dimensions shall be tested at random by the manufacturer, one for each duct reel, during the manufacturing process. A copy of all measurement reports shall be provided.

All documentation and measurement about the HDPE duct along the line shall be included in a Quality control Book, to be produced by the Contractor.

5.0 Termination and Splicing of Fibre Optic Cable

The system shall be designed to operate in ambient site and climatic conditions. For outdoor splice enclosure and underground splice enclosure, the Contractor shall guarantee correct operation under the prevailing site and climatic conditions.

The Manufacturer / Contractor shall assure that the cable joints time of life shall be at least 25 years under the installation conditions.

The splicing shall be done inside Manhole as per the spec. and dwg.

5.1 Optical Termination at both end of the control rooms.

Optical fibre cable shall be terminated on suitable Optical Distribution Frames (ODF). All fibres in the cable shall be terminated in the ODF in to the fibre optic core switches.

Termination shall utilize ST type connectors for all fibres (spare and used) in the cables. All spare fibre terminations shall be sealed with proper caps to prevent entry of dust or other contaminants to the fibre end.

Patching from line side to Optical Line Terminating Equipment (OLTE) side shall be made by rugged optical patch cords. Losses for the connection coupling shall not exceed 0.5 dB and each shall be considered in the power budget calculations. For each fibre optic link, a minimum of 3 dB safety margin should be provided after accounting for the following losses:

Connectors losses
Cable Attenuation
Splice losses

Future cable splices losses.

This shall normally be taken as 3 dB

5.2 Optical Splicing

The splicing of optical fibres shall be made by arc-fusion method. The single splices, together with surplus length of fibre, shall be arranged in an orderly way into a proper splice enclosure.

The maximum splice loss for each fibre link shall not exceed 0.2 dB, however the average splice loss for each fibre link shall not exceed 0.1 dB.

The minimum number of intermediate splices shall be utilised, compatible with a suitable cable overhead installation or laying in trench strategy.

Splices shall be housed in outdoor or underground fully weather sealed enclosures especially designed. The IP rating for such enclosures should be IP 66, but minimum IP 65 shall be assured and certified in case of **outdoor/above ground** splices. If the splicing points are **undergroun**d, the IP rating for such enclosures shall be certified as IP 68.

All splices shall be clearly numbered in an overall numbering scheme, which shall be detailed in the as built documentation. These numbers shall also appear on surface splice enclosures. At splice enclosures the

cables shall be marked upon entry indicating the destination of each cable end. All fibres shall be spliced for each optical section.

6 Testing and installation

Note: Various tests outlined in this section supplement testing clauses elsewhere within sections of the Specification. Where any discrepancy or contradiction arises between these various sections of the Specification, the telecommunications systems testing clauses shall take precedence and supersede those other testing clauses.

6.1 Dimensional Tests on Fibre Optic Cable

The supplier shall carry out testson incoming goods, to verify the integrity of the materials manufactured.

Tube dimension:	Inner diameter measurement
(With tolerance +10%)	Outer diameter measurement
Sheath thickness	Nominal measurement
(With tolerance +10%)	Average measurement
Outer diameter	Minimum measurement
(With tolerance +10%)	Nominal measurement

6.2 Factory Acceptance Test for Optic Cable

The tests shall include for each testing length optical time domain reflectometry measurement for testing length and attenuation. For runs over 100 meters, the test shall be made at both ends and the two measurements compared. Differences greater than that which can be caused from instrument resolution shall be investigated and resolved

The contactor shall propose the third party inspector from the MEW approved inspectors list at his own cost to carryout FAT (Factory acceptance test) as per the approved Inspection and Test Plan (ITP)

The contractor /vendor shall submit the ITP and approved before carry out the TPI FAT.

The FAT reports must be submitted to MEW and approved before shipping /transporting the cable drum to the site.

Attenuation shall be measured to ensure compliance with the design specification.

The measurements shall be summarized in a graphic (back scattering diagram) which shall also be used for localized losses detection during installation.

In particular the test carried out by the supplier shall be the following:

- Attenuation measurements for each fibre in dB/km (average and maximum) in all the cable lengths of the supplied lot.

- General inspection on construction conformance.

Moreover for each fibre:

- Attenuation coefficient for 1310nm, for cable Avg (db/km)
- Attenuation coefficient for 1550nm, for cable Avg (db/km)
- Zero dispersion wave length,
- Zero dispersion slopes,
- Chromatic dispersion at 1550nm, 1310mm (ps/nm.km)
- Mode field diameter (micro m)
- Cable cutoff wavelength
- Cladding diameter
- Coating diameter

All cables with values above the specified shall be rejected.

Tests to be performed by the supplier witnessed/certified and approved by the contractor and the Engineer, shall demonstrate that the communication system has been provided and constructed in accordance with the specifications and standards.

The Contractor shall submit a comprehensive test schedule for the company / contractor approval at least 4 weeks prior to the start of the test.

Moreover, the Contractor shall demonstrate that the following type tests or equivalents were performed on fibre optical cable in a manner to guarantee the quality of the production process. MECHANICAL REQUIREMENTS FOR FOC AS PER IEC-794-1

Description	**Minimum Requirement**
Compressive strength	12.6 N/mm
Impact Resistance	50 N.m, cycles, 0.5 Hammer Radius
	10 N.m, 10 cycles, no fibre break
Cable twist	10 cycles, 180° twisting, 2.0 meter sample
Tensile load	Static: 1000N
	Dynamic: 2700 N
	(At 3400N no fibre break)
Water penetration	3 meter sample, 1 meter water pressure, 24 hours
Compound flow test	No drip at 85 °C
Repeated bending	500 cycles, 100 N cable load, 20 x OD Bend radius, 30±1 cycles/minute, 5 meter sample minimum.
Temperature cycling	-20°C to 85°C
Jacket adhesion strength	1.8 N/mm
Bend radius	Armoured:15 x OD (Static)
	20 x OD (Dynamic)
	Non armoured: 10 x OD (static), 20 x OD (dynamic)
Hot/cold bend	-30°C and 85°C, 20 x OD Bend Radius, 100 N cable load

The following to be as per IEC 794-1

Maximum Pulling Tension (MPT)
Min. Pulling Bending Radius at MPT.
Crush resistance

Cable design life

Notes:

- The average increase in attenuation for the fibre of a cable subjected to this load shall not be greater than 0.10dB, and no measurable increase in attenuation shall be evident after the load removal.
- The cable sample shall withstand impact testing without exhibiting and average increase in attenuation greater than 0.20 dB. The cable jacket and armour (if present) shall not exhibit evidence of cracking or splitting.
- The cable sample shall be capable of withstanding mechanical twisting without experiencing an average increase in attenuation greater than 0.10 dB.
- The average increase in attenuation for the fibre of a cable subjected to the dynamic load shall not be greater than 0.10dB. The cable shall not experience a measurable increase in attenuation when subject to the static load.
- The cable sample shall be capable of withstanding mechanical flexing without experiencing an average increase in attenuation greater than 0.10 dB at the completion of the test. The cable jacket and armour (if present) shall not exhibit evidence of cracking or splitting under 10 times magnification.

  The change in attenuation at extreme operational temperatures shall not be greater than 0.20 dB/km, with 80 % of the measured values no greater than 0.10 dB/km. The measurement shall be made at 1550 nm wavelength.

  Four test samples shall be taken on the overlap region shifted 90° one the other.
- The average increase in fibre attenuation at the extreme test temperatures shall not be greater than 0.20dB. The cable jacket and armour (if present) shall not exhibit evidence of cracking or splitting.

Environmental Characteristics

- Low temperature test

The maximum variation of attenuation at 1310 nm and 1550 nm between ambient temperature and -30°C is within the measurement error of the apparatus.

- Temperature cycling

  The maximum variation of attenuation at 1310 nm and 1550 nm with respect to ambient temperature in the range between -60°C and + 85°C is 0.05 dB/km.

Special tests

The Contractor shall demonstrate by means of suitable certification that the following type tests or equivalent were performed on the fibre optical in manner to guarantee the quality of the production process.

- Tensile breaking strength on long sample can be given in the Weibull distribution form,
- Bending,
- Very high temperature resistance (e.g. 180°C or +200°C),
- Nuclear radiation,
- Stress corrosion susceptibility factor N,
- Dynamic strength,
- Abrasion,
- Micro bending sensitivity.

6.3 Acceptance Tests (Final Inspection)

The tests shall include for each testing length optical time domain reflectometry measurement for testing length and attenuation. For runs over 100 metres, the test shall be made at both ends and the two measurements compared. Differences greater than that which could be caused from instrument resolution shall be investigated and resolved. Attenuation shall be measured to ensure compliance with the design specification.

The measurements shall be summarised in a graphic (Back Scattering Diagram) which shall also be used for localised losses detection during installation. In particular the tests carried out by Supplier shall be the following:

Attenuation measurements for each fibre in dB/km (average and minimum) in all the cable lengths of the supplied lot.

Moreover for each fibre:

- Attenuation coefficient for 1310 nm and 1550 nm
- Zero dispersion wave length
- Zero dispersion slopes
- Chromatic dispersion at 1550 nm

All cables with values above the specified will be rejected.

Tests to be performed by the supplier, witnessed/certificated and approved by third party inspectors or MEW Engineer in accordance with inspection data sheet shall demonstrate that the communication system has been provided and constructed in accordance with the specifications and applicable standards. The Contractor shall submit at least four (4) weeks prior to the start of the test

6.4 Inspection and Testing of Ducts

During manufacturing all the tests shall be performed by the Contractor in order to assure duct performance.

The Contractor shall carry out tests on incoming goods to verify the integrity of the materials to be used for the manufacturing.

All in line tests shall be certified.

Moreover copies of Certificate of Origin relative to primary HDPE material shall be provided. Dimensions shall be tested random by the manufacturer (one for each duct reel) during the manufacturing process.

A copy of all measurement reports shall be delivered.

All documentation and measurements about the HDPE duct along the line shall be included in a Quality Control Book (produced by the vendor).

6.5 Installation of Fibre Optic Cable

The installation of the telecommunication cable into the duct consists of:

- First simple visual inspection of the cable integrity;
- Cable reel allocation;
- Lay of the cable;

For these operations the Contractor shall provide specialized personnel with the necessary tools and instruments.

These operations shall be done respecting the project specifications and mechanical characteristics of the cable.

Preliminary Services

Prior to starting the services, an on-site analysis of the existing duct shall be made, to determine the cable reel allocation, the points where to thread the cable into the duct and to place cable rollers. The nylon draw

rope shall be 10mm dia situated with the steel pulling rope by a capstan winch that haul the rope to the point where the cable reel shall be positioned.

An articulated anti-torsion joint shall be fixed to the end of the steel rope and, with a hauling sleeve, bind at the end of the cable.

Cable Pulling-In

A capstan winch with a mechanical fuse that protects the cable from excessive tension stresses shall do the cable pulling-in.

An appropriate lubricant should be used to facilitate cable pulling-in, applying it both on the cable and the duct.

If more than one capstan winch is available, the other ones should be positioned in middle draw pits to provide synchronous cable pulling and more than 1 Km pulling at once.

If the cable has to be pulled-in in two directions, the cable shall be positioned at the centre of the spread and the cable pulled-in in one direction, than the cable left shall be figured in eight shapes to be pulled-in in the other direction with the same method.

Cable Positioning in Draw pits

After the cable has been pulled-in into the duct, appropriate end caps shall cover the cable ends.

In all draw pits a cable spare of about 5 m shall be placed; in the draw pits where a cable splice should be done.

If more cable exceed, the cable spare shall be distributed along intermediate draw pits. Open-end plugs shall block the cable exit from the line duct.

7.0 Installation of Ducts For Telecommunication Cable;

7.1 General

The duct for telecommunication cables shall be manufactured in circular extruded UPVC, nominal diameter (ND) 200 mm, 4.5 mm min. thickness.

The HDPE ducts shall be designed to protect the cables across road crossing.

7.2 Accessories

All the required components to make the duct continuous and useful for installation of the telecommunication cable, which are:

Nylon draw rope: to haul the steel pulling in rope for the telecommunication cable; End plugs: to close the end of the duct;

Open end plugs: to close the end of the duct and centre the cable;

Pushing mandrel: to haul the draw rope into the duct with an air compressor.

7.3 Installation of Concrete Draw pits

The duct shall be interrupted every vortex more than 45°, to insert a concrete draw pit, which is similar to pipe line manhole typical and have vertical walls to permit duct entry in every direction, as per the drawings and subject to the engineer approval.

The position of every pit will be specified and the subcontractor shall respect the following directives:

The excavation to place the draw pits shall be 200 mm larger than the pits.

After the excavation the laying surface shall be levelled to lay the pit perfectly horizontal.

If the pit is a pre-formed one and made of more than one element, the elements shall be sealed by concrete mortar.

The duct shall be inserted into the pit for at the same level of pipe, and the entry shall be sealed by concrete mortar.

The base of the pit shall have a hole to drain water. 7.4

Installation of the Duct

The duct installation shall be located at the same level of pipeline depth, and to be straight strokes, with draw pits between them, to assure the installation of the draw rope, the place for telecommunication cable joints and the easier hauling for the cable.

Crossing

- Open air crossing
- The duct shall be fixed to the pipeline with the proper attach clamps.
- Casing pipe crossing

If the pipeline is protected by a casing pipe, the duct shall be fixed on the ceiling of the concrete casing with proper supports

Pipeline crossing

In the case of pipeline crossing, the duct shall be laid above the pipeline, at a minimum distance of 300 mm, constituted of sand bags.

Duct Splices

The splicing between segments of duct should be done at least 24 hours after the laying, to be sure that the duct has met the final configuration.

All the splices shall be done by a butt welding machine and it shall be faultless to minimise its resistance in cable pulling.

Alternatively compression joints should be used.

Installation of steel wired warning tape

A warning tape shall be provided to warn of the presence of the duct and the relative telecommunication cable to avoid eventual damage to the duct during an excavation. It shall be in red polyethylene, alkaline and acid chemical agent proof, 50 mm wide, 1micron mm thick, steel wired and shall be wound onto reels 300 - 400 m in length.

Installation of warning tape shall be done during covering, on the vertical axis 300 mm above the PVC tile. The tape shall be arranged continuous making necessary splicing.

The warning tape shall be signed in English and Arabic. The tape shall read: CAUTION! FIBRE OPTIC TELECOMMUNICATION CABLE. " from ----- to-----

Installation of Draw Rope

A nylon draw rope shall be placed into the duct to successfully haul the steel wire for installation of the telecommunication cable.

The installation shall be made using a compressed-air pushing mandrel, with diameter slightly smaller than that of the duct, that carried the draw rope from one end of the duct to the other.

This operation shall be done immediately after duct covering to be sure that the duct has no damages or obstructions.

Mapping and Recording

The Sub-contractor shall store on the appropriate sheets, all the drawpits, duct splices or reparations, special protections, etc. to make the positions easily detectable, specially: -

Every cable position change or pipeline crossing;

- Crossing in casing pipe;
- Splices and or reparations;

- Progressive metric marker.

All duct splices or reparations shall be stored also on the splices diagram.

8.0 TRENCH EXCAVATION FOR CABLE

Excavation for fibre cable trenches will be carried out on completion of backfilling to the water main trench, unless otherwise agreed by the MEW/Engineer.

Trenches shall be to a depth of 1.5 m below (2m dept depth at the road crossing) the final formation level or existing ground level whichever is the lower and in accordance with the routes shown on the Drawings. Bottoms of trenches shall be levelled and smoothed and shall not be less than 700 mm in width. Cables shall be laid in the trenches on the trench centre line. After the cables are laid the trench shall be backfilled with 250mm of fine selected soil free from lumps, metallic or other foreign matter. Standard cable cover PVC tiles as specified herein shall then be laid centrally along the line of the cables on the vertical axis 400 mm below the warring tape and above F.OC... The remaining of the trench shall be backfilled with fine sand in accordance with spec. Trenches shall be excavated and measured separately from water main trenches, unless otherwise agreed by the MEW/Engineer. The more details of cable trench details shall refer to the tender drawings.

Cable laying shall be carried out with care. On straight runs the cables shall be laid from the drum directly in the trench and pulled in the trench using an adequate number of rollers. The cables shall be pulled straight, but without undue tension.. On curved routes the spacing shall be maintained. The method of cable laying shall be approved by the MEW/Engineer prior to the commencement of the work. When required the Contractor shall excavate by hand with or without the use of picks or bars as instructed with no extra compensation.

Cable joints shall be made in the manner recommended by the cable Manufacturer and to the satisfaction of the MEW/Engineer

The Contractor shall fulfil the following requirements:

a. The Contractor shall give the MEW/Engineer twenty-four hour notice in writing that the trench is ready for inspection before laying any cables.

b. If the MEW/Engineer does not approve the trench or the cables laid, the Contractor shall make good as directed by the MEW/Engineer and give a new notice or readiness for re-inspection.

Soil conditions and ground levels vary in Kuwait. In some cases, where obstacles such as existing services are met, it may be necessary to lay the cables at depths exceeding 1.5 m. Where necessary the Contractor shall make trial excavations ahead of trench excavation to determine the exact location of existing obstacles. The Contractor shall proceed with caution in the excavation and preparation of the trench so that exact location of underground obstacles both known and unknown, may be determined, and he shall be held responsible for all costs resulting from the damage, interruption or breakage of any services, structures or other obstacles.. In the event of any damage, interruption or breakage to the existing facilities and services during the progress of the work due to the failure of the Contractor to exercise proper precautions, the Contractor will be held liable for all costs resulting from the damage, interruption or breakage of the said facilities and services.

The Contractor shall, at his expense, pump out all water or sewage which may arise or be brought into excavations of any kind from the existing sewers, drains and water courses or from rainfall or flash storms and shall, where necessary, thoroughly drain the Works.

Where cables cross certain major roads they shall be located in reinforced concrete culverts which will also contain the water mains. Cables shall be drawn through 160 mm diameter x 6.3mm thick HDPE ducts fixed to the concrete walls as shown on the Drawings. The Contractor is to include in his rates for the supply of the necessary materials and the labour required for the fixing. At some locations where cables cross roads they shall be laid in 160 mm dia 6.3mm thick HDPE ducts as shown on the Drawings.
The rates given for excavation shall be deemed to include for all costs involved in complying with the Clauses under this Section of these Specifications. The Contractor shall be allowed no extra compensation for any reason whatsoever.

The price shall include for HDPE cable duct direct jacking under every road crossing with necessary manhole and accessories to be provided.

9.1CABLE RECORDS

The Contractor shall engage at least one qualified surveyor and one qualified draughtsman to furnish the cable records.

The Contractor shall prepare the cable records taking accurate measurements at site in an approved manner and these measurements shall be approved by the MEW/Engineer before backfilling of the trenches.

The Contractor shall hand over the cable records after completion of each cable line. The Contractor shall also hand over to the MEW/Engineer all the preliminary working sheets or records prepared at site.

The Contractor shall include for the cost of preparation of cable records as described above in the rates quoted in the Bills of Quantities.

9.2WORK IN TILED PAVEMENTS

Removal and restoration of tiles shall be carried out in accordance with the requirements.

9.3CABLE COVER PVC TILES SLAB

The Contractor shall submit Test Certificates for the tiles to the satisfaction of the MEW/Engineer.

Cable cover tiles shall be made from PVC, Size 1000x150x6mm thick.

The cable tiles shall have cast-in warnings in English and Arabic on the upper surface.

9.4 CABLE JOINTING

Cable jointing/splicing shall be carried out according to the recommendation of the cable Manufacturer.

The Contractor shall submit with his Tender details of the method and procedures of cable jointing /splicing he proposes to use giving details of the materials to be used.

Each section of the cable shall be tested before jointing and cables and joints shall be tested after jointing.

The Cable to be tested at site before laying into the trench

Test procedures and test instruments to be used shall be approved by the MEW/Engineer before any instruments and/or equipment are ordered by the Contractor.

The Contractor shall provide the test instruments and skilled personnel for carrying out the tests. Instruments shall carry a current test certificate of approval from an approved testing authority.

The cable jointing and the tests shall be carried out under the supervision of the MEW/Engineer.

If the tests are not satisfactory the MEW/Engineer may require the Contractor to remake the joint and the Contractor shall do so at his own expense including the supply of materials and labour to the satisfaction of the MEW/Engineer. The tests shall be repeated at the Contractor's expense.

The satisfactory test results shall be recorded for each joint and section of the route and six copies of each record shall be submitted as part of the record drawings by the Contractor.

10.0 MEASUREMENT AND PAYMENT

10.1 Basis of Measurement and Payment

a. General;

Measurement and payment for cable ducts shall be in accordance with the Specifications and actual laid in the site and certificated by the engineer..

b. Cables;

Measurement and payment for Fibre Optic cables shall be in accordance with the Specifications. Rates shall include for all necessary accessories.

c. Ducts;

Measurement and payment for ducts in concrete shall be in accordance with the Specifications. Rate shall include supplying and laying the ducts, including all necessary jointing accessories, supplying and laying of concrete, ducts markers slabs ,all necessary accessories as specified.

11. MAINTENANCE AND GUARANTEE PERIOD;

Maintenance guarantee period shall start from the successful completion of one month's reliability test period and the Engineer approval of all documents and manuals pertaining to the work carried out and materials supplied under this Contract.

There will be two years maintenance guarantee period for the cable installation and equipment under the Contract. The Contractor shall at his own expense repair or replace the defective equipment or part thereof by a direct replacement new substitute of the same kind and make and to the approval of the Engineer.

Maintenance shall include Routine Maintenance and Repair and replacement of defective parts and installation, which include all labour and materials.

12.0 Inspection and Check list.

REQUEST FOR MATERIAL INSPECTION – CHECK LIST:-
(Fiber optic cable work)

Inspection required	Date:	Time:	
Subject	Fiber optic cable drum Visual and Attenuation test inspection (before laying)		
Location			
B.O.Q No	Shop Dwg:-	Spec Div:-	Section No:-

Description of works to be inspected			
	1	Visual inspection	
	2	OTDR (Optical Time Domain Reflectometer)	
	3	OLTE (Optical Line Terminal equipment)	
	4	Patch cards/Panels	
	5	Optical splicing	
	6	Cable pulling-In	
	7	Optical termination	
	8	HDPE cable duct	
	9	Duct splices	
	10	Installation Draw rope	
	11	Installation of warning tape	
	12	Concrete drawpits Manhole/Hand hole	
	13	Mapping and recording (Route marker/identification)	

Enclosed documents/ Drawings: 1. Visual and Attenuation test inspection report.
2. Manufacturer Factory test reports.

Comments:
The contractor agreed to make the attenuation test after laying/before splicing the F.O Cable.

NB: This checking & approval shall not relieve the contractor of his obligation to perform the work in accordance with the contract specification/documents.

ME W – Projects:- _____ _____ _____ _____

Engineer's representative Name Signature Date Time	
MEW – O&M:- _____ _____ _____ _____ Engineer's representative Name Signature Date Time	
Contractors _____ _____ _____ _____ representative Name Signature Date Time	

Visual and Attenuation test reports

1. Cable Identification No.:
   Drum No. :
   Length (meters) :
   Attenuation test results :

Fiber count	Tube colour	Fiber colour	Attenuation			
			DB/kilometer		total loss	
			1310nm	1550nm	10nm	1550nm
1	Blue	Blue				
2	Blue	Orange				
3	Blue	Green				
4	Blue	Brown				
-						
-						
12						

Average Attenuation (DB/KM) =
Max Attenuation (DB/KM) =

2. Cable Identification No.:
   Drum No. :
   Length (meters) :
   Attenuation test results :

Fiber count	Tube colour	Fiber colour	Attenuation			1310nm
			1550nm	total loss		
1	Blue	Blue				
2	Blue	Orange				
3	Blue	Green				
4	Blue	Brown				
5						
‘’						
11						
12						

Average Attenuation (DB/KM) =
Max Attenuation (DB/KM) =

3. Cable Identification No.:
   Drum No. :
   Length (meters) :
   Attenuation test results :

Fiber count	Tube colour	Fiber colour	Attenuation 1550nm		total loss	1310nm
1	Blue	Blue				
2	Blue	Orange				
3	Blue	Green				
4	Blue	Brown				

Max Attenuation (DB/KM) =

End of Particular Specifications

Government of State of Kuwait
Ministry of Electricity and Water

Section 4C.15

Technical Specification for

GRP(Glass Reinforced Plastic)Panel

Panels - Glass Reinforced Plastic (GRP)

The GRP panel to be designed and installed at storage Reservoir and Water Tower complex to protect against sun radiation for the equipments as per the particular specifications with all necessary accessories;

The scope includes to
Supply and install customized Portable ISO furnished GRP container/shelter, size 2.0mtr (L) x 1.5 mtr (W) x 2.5 mtr (H), With Patricians. The cabinet shall supply furnished ceilings, floors, Sliding windows, double doors, with heat insulation, filters, louvers, etc.. to protect heat, humidity, moisture and proper ventilation. The cabinet shall be provide with necessary accessories such as Power socket, split a/c, Fluorescent lighting, Wall mounted J-box, intercom phone to control room, door limit switches, temperature switches (hardwired to DCS), Stainless steel trays, R.C foundation, mounting frame with installation accessories, etc.. Install the location as shown on the drawings.

This specification described as minimum requirements, however the vendor shall provide all the features including mounting plates, earth busbar, marshalling terminals, drawing pockets, lights, ventilation system, tag plates, SS316L glands with shroud, etc.. as mentioned in the international and manufacturer std.

The vendor shall provide the General Arrangement drawings for MEW approval.

Any panel required to be installed outside buildings shall unless otherwise approved by the Engineer be manufactured from double-skin, resin-bonded fibreglass, with a totally encapsulated infill of rigid weatherproof and "boilproof" plywood to BS 1203 between the two skins to provide a rigid and vandal proof enclosure. The environmental rating shall be IP 55 or better.

The roof section shall be sloping and have a totally encapsulated infill of end-grain balsa instead of plywood.

Box section steel shall be encapsulated into door edges and door frames. Door locks, handles and hinges shall be of a high tensile strength, non-corroding alloy with stainless steel pins and through fixing bolts. Large plane surfaces shall have adequate reinforcing to ensure rigidity.

The doors shall be complete with latching handles and locks. All door catches and locks shall latch onto steel reinforced surfaces.

Threaded studs shall be incorporated into the design of the panel for the mounting of sub frames within the panel. Any panel drilled to provide fixings for internal equipment will not be accepted.

Each cubicle shall be provided with a floor or deck with a removable gland plate for cable entry.

The laminate material shall have flame retardant characteristics in compliance with BS 476 1971 Pt.7 Class 2, and shall retain "stability, integrity and insulation" for 30 mins when tested to BS 476 Pt 8.

Colour impregnated gel coats backed by coloured resin shall be used to ensure maintenance free and "colour fast" finishes. The external finish colour shall be advised by the

Engineer and the internal finish colour shall be white.

The fronts of externally - visible instruments and windows shall be of glass. An air- gap of 100 mm shall be provided between the top surface of the panel and its protective canopy.

All internal equipment shall be mounted on supports built into the fibreglass structure. Fixing bolts through the skin will not be accepted.

Government of State of Kuwait
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Section 4C.16

Technical Specification for

Control Room Hardware_ Display Wall (DLP), Consoles

Display Wall, Controller and related Software

1. General

The Display Wall is the most visible part of the Control room and therefore particular attention should be paid to the performance, quality, flexibility, user friendliness and integration aspects of the entire system as a whole.

The bidders shall provide a document confirming the capability to support the technology proposed for a life span of at least 7 years.

The products have to be designed, engineered and produced by a single manufacturer and integrated into video surveillance system LAN network system for monitoring the real time video in full HD with full resolution qualities.

The contractor shall provide full detailed documents proving the capacity of the manufacturer to completely fulfill these requirements.

The client reserves the right to ask at any given time to visit the R&D facility, production and testing facility to verify these conditions.

2. Technical specification display walls

The display system shall be the most advanced display technology and should be the state of the art in large display solutions.

It must have a uniform picture, where the projection modules has to display a complete uniform picture over the entire screen. No artifacts, color difference, motion distortion or latency has to be visible at any time and in any conditions.

The technology to be used shall be DLP rear projection using full HD LED as illumination. The size of the display cubes shall be of 70".

Minimum detailed specifications for the display modules:

- The video wall shall use 70" DLP-based Display Modules with solid state full HD (LED) illumination with a lifetime of minimum 7 years in 24/7 operation.
- The video wall and its components shall be specifically designed for 24/7 use
- The display modules shall use solid-state illumination (LED) The display modules shall have no color wheels.
- The native resolution of each display module shall be full HD (LED) 1920 x 1080 pixels with aspect ratio of each display module being 4:3 or better.
- When connected to a graphical card driving the native resolution full HD (LED) – 1920 x 1080, all pixels shall be shown 1:1 on the display module, without scaling or softening of the image.
- The highest brightness of the solution as per manufacturer std.
- The minimal display gamut shall be EBU (as defined in ITU-R.BT Rec.709).
- The minimal ANSI 13 luminance uniformity shall be 95%
- The projection system of the display module shall have redundant LEDs (if one of the LEDs fails, the other still work and the image is not lost).

- The projector modules shall come pre-calibrated, so that it shall not be necessary to calibrate the display modules after installation in order to achieve a uniform display wall (brightness and color).
- During the useful lifetime of the illumination unit, there shall be real-time automatic color and brightness alignment of different projectors to a reference, resulting in a perfectly uniform display wall.
- An auto-calibration system shall measure the brightness of white and of each primary color.
- No external recalibration shall be necessary during the useful lifetime of the illumination unit.
- The real-time automatic color and brightness alignment shall be done in the background, without any downtime or temporary loss of content.
- No mechanical bezel shall be present.
- No input data shall be lost within the screen gaps.
- The screen gap shall not exceed 0.1 mm when stitched, and not more than 0.2mm if modular.
- Each display module shall have two HDMI inputs and two HDMI loop-through outputs for redundancy purposes.
- Each HDMI input and output shall be Dual-Link HDMI.
- It shall be possible to configure the inputs so that the second input becomes active if the signal is lost on the first input.
- In case the second input becomes active if the signal is lost on the first input, it shall be possible to configure the inputs so that the first input becomes active when the signal on it is restored.
- The acoustic noise of the display module shall not exceed 40 dB(A) at 1 m.
- The projection engine shall be fixed to the cube so that it cannot cause misalignment.
- Remote control and management of display wall for ease of maintenance with the following features:
  - Switch On/Off
  - Manual Adjustment of Brightness, White Point and Color Gamut
  - Input Switching
  - Get health status of each display and of the full system
  - Perform the above actions over an Ethernet network
  - Be able to monitor multiple display walls from one user interface
  - Generating logs on use time, healthy status, malfunctions, alerts
- The display wall subsystem has to be controllable via external applications using specific interfaces and Ethernet IP base network connection.

3. Technical specification of the Display Wall Controller

The graphical controller is the unit that shall generate all the information that has to be displayed on the visualization system.

- An open architecture with extensive use of industry standards to provide the required scalability
- Flexible and economical support for any system size and any input demand
- State-of-the-art processing power combined with the integration flexibility of a standard PCI bus based PC
- Extensively evaluated PC components combined with redundancy options guaranteeing optimal reliability and performance
- The Controller shall be designed to allow integration and display of all kinds of data sources with Input Cards providing dedicated input capabilities for the widest range of source types to be found in typical control room scenarios.
- Quality of Service (QoS) by separating graphic data and network traffic from Bandwidth - demanding input data
- It shall be flexibly configurable according to the requirements of the application. Typically, adding inputs or outputs to a system shall be achieved by means of adding an input card or an output card and possibly an additional card cage.

- For uninterrupted system operation it shall include redundancy with
    - Redundant hot-swap power supplies
    - Redundant hot-swap RAID Level 5
    - Redundant Ethernet (LAN) adapter
    - The redundancy components shall be continuously monitored

The controller shall be equipped with the required number of input, scaling, and output cards to allow the configuration of images as required on the wall. Input cards shall be available for all RGB/DVI, HDMI, analog or digital (SDI) video and streaming video.

4. Technical specification of the Software

The software shall provide the following feature:

- The control room management suite shall provide operators and decision-makers with easy access to information and allow them to connect to multiple sources, to configure how they are displayed, and to collaborate in the most efficient way.
- The software should enable users to easily connect to a multitude of sources, regardless of where the information has to be presented – on small LED displays, video walls or operator workstations.
- The software should offer nearly unlimited possibilities to control and manage displays and sources.
- The software, should have redefined control room collaboration through the unique concept of Perspectives, control management suit allows to make more efficient use of the control room display estate, and to share user-defined information views more efficiently.
- Visualizing any information anytime, anywhere: the software should allow to monitor operations and visualize real-time content from anywhere in the control room facility. Be it on a small display, a workstation or a video wall, the sources can be distributed and displayed as many times as required in any location.
- Efficient use of display estate: the software should contain a set of advanced features which allow operators to easily work with high-density information and share it more efficiently. For example, an operator can compose a personal layout with a variety of sources, but only send part of the information to a video wall, which really needs to be shared with the group or a supervisor.
- The software should allow operators to define, select and share their own Perspective according to the current situation and share it with other operators. Looking at the same visual information allows for faster and more efficient communication and briefing, and hence for faster and better coordinated responses to incidents in the field.

- Supported sources:
    - Analog and digital PC sources (DVI & RGB), HDMI
    - Screen scraping of Unix and Microsoft Windows servers and workstations & applications
    - Web based applications, portals and internet sources
    - Application management on displays
    - Analog video (composite)
    - Streaming video, including HD/H.264, MPEG2, MPEG4 and JPEG2000 streams
    - Full support for various video formats, both file-based or streams, by using Microsoft Windows Media Player technology

- The minimum functionality that the software shall provide for easy and flexible use of the Display Wall shall be as follows;

- Controlling of the applications, start/stop, positioning windows, defining regions and privileges on application level
- Controlling the external input sources
- Defining layout as combination of applications, applications windows, external sources windows
- Starting/stopping different layout
- Controlling all these process from different workstation connected via LAN with the controller
- Give Software Remote Pointer facilities; from any workstation the operator should be able to use his local mouse/keyboard on the display wall
- API programming interface facilities for an easy integration with other software in order to design the monitoring system as a unique logical entity.

5. Operators consoles

Bidders are requested to propose manufacturers who have a minimum of twenty five (25) years experience specializing in console design and fabrication in addition to ISO 9001 certification as a measure of consistent quality and performance.

The consoles offered shall be of a modular structural system that shall support a full range of layouts and control room configurations taking into consideration the possibility of future expansion or reconfiguration

The console shall be available in reduced depths (980 – 990mm) that shall accommodate flat panel displays in a minimal footprint

Creative design layouts shall be achieved with integrated corners and mitres.

The console shall have the ability to have flat screen monitors and various desk accessories mounted on the rear slatwall.

Front and rear access doors shall provide high accessibility for installing, operating and servicing equipment. It shall be possible to access the front and back through hinged lipped doors.

The console shall accommodate computer equipment with a variety of optional processor shelves. Fixed or slide out shelves shall be available with the hinged panels.

The console shall provide convenient open cable chases that run uninterrupted to adjacent desks in the upper and lower portion of the base units. The integrated cable tray shall be accessible by removing the access panel on the worksurface.

The standard finish for the monitor deck is high plastic laminate (HPL) on both sides of the work surface. A variety of cable management options accommodate electrical and data service.

6. CONSOLE MATERIAL SPECIFICATION

Console Frame Structure All sheet metal used for structural components shall be cold rolled steel. These components ensure square, rigid connection of the front portal to the rear frame assembly, module-to-module connections at corner positions, and attachment of front, rear and end panels. Sheet metal parts to be produced on CNC machines to ensure precision. All sheet metal parts must be finished with a durable, black, electrostatic powder coating.

- **Work surfaces and Panels**
  - Panels and worksurfaces shall have the following properties:
  - Materials: 1” (25mm) particleboard, high-pressure laminate surface
  - Finish Horizontal grade laminate.
  - Static Load 50-lb./ linear ft.
  - Panels: hinged panels as a standard for front and back.
  - End Panels: 1 in Thermo fused Melamine Laminate (LPL).
  - Lower/Intermediate Panels: ¾ in Thermo fused Melamine Laminate (LPL).

- **Rounded Polyurethane Worksurface**

  Polyurethane foam secured over an aluminum extrusion carrier.

The nosing shall allow for curved sections with a 14 in radius with an edge slope and radius to spread the weight over a larger surface.

- **Other accessories to be provided;**

- **Power bar:** Industrial Grade Power Bar.

- **Ventilation Fan**: Fans shall be available for mounting on the doors or wire tray and shall be provided as required in each individual situation.

- **Slide-out mouse trays** for under-counter keyboard drawer (left or right side).

- Articulating monitor arm depending on console configuration

7. Technical documentation

The bidder shall provide a set of documentation, this documentation shall cover the required technical items, including a mechanical drawing of the proposed system.

7.1 Documentation

- Layout drawings.
- Full technical literature for the equipment offered.
- Software documentation.
- Compliance statement with the specification and data sheet requirements.
- A list of all accessory items together with MANUFACTURER's name and part number.
- The VENDOR shall provide a completed copy of the data sheets with all changes entered.

7.2 Document Required for Approval

- Control Room Survey reports.
- General Arrangement / Construction Drawings
- Overall dimensions of equipment.
- Control Room equipments (Wall display, Console, Printer, Control Panel, furniture, etc..) layout.
- Design Calculations
- Functional Design Specifications.
- Software Detailed Specifications.
- Interface with LAN system.
- Full technical literature for the equipment.
- Material test certificates
- Quality Control Manual and Quality Plan

- On receipt of written approval, the MANUFACTURER shall submit to the MEW all approved documents as listed above.

- Prior to shipment, the MANUFACTURER shall submit the test certificates

- Documents shall be in the English Language.

8. Quality Assurance

The bidder shall provide all his Quality assurance certificates and the related Quality Procedures

9. Support

The bidder shall describe the support possibilities for the proposed system through a local agent who has previous experience in such installations (reference list with at least a minimum 10 local installations shall be included).

10. SPARE PARTS

The MANUFACTURER shall provide the recommend spare parts on the following basis:

- Commissioning spares
- Two (2) years operation spares

The commissioning and operations spares to be handed over to MEW store.

The price for the spare parts shall be included in the respective items of the BOQs.

The spare parts as specified in the BOQ Should not used for the commissioning and two years operations, to be provided separately

Government of State of Kuwait
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Section 4C.17

Technical Specification for Industrial type

UPS and Battery system

UPS System

Part 1 General 1.01

Description

This specification sets out the requirement of the UPS system. The work comprises the supply and installation of all services, equipment, components, accessories and fittings required for the operation of the UPS system.

UPS System and DC Power Supply System

A The UPS system and DC power supply system shall meet commonly the operational and rating requirement as follows:

Type	indoor, self-standing, metal enclosed
Structure	
Structural parts	Min. steel plate thickness (mm)
Side plate	According manufacturer std. and subject to MEW Engineer approval
Bottom plate	
Roof	
Ceiling	
Separator	
Door	
Shielding plate	
Nameplate	Plastic plate, with engraved black letter on white back-ground.
Power supply	AC 415 V, 50 Hz, 3-pahse, 4-wire
Rated output	AC 240 V & 3 phase.
Rated short time current	capable of withstanding the system short-time current
Enclosure	corrosion protection, coated steel enclosure
Protection level	IP21
Pulse number of converter	18-pulse or IGBT

Charger

Type Thyristor or transistor type, floating charge, 3-phase full-wave rectification

Inverter

Type Thyristor or transistor type, pulse width modulation inverter

Operating method Inverter constant operation with synchronous and uninterruptible change over from normal power supply.

Back-up time As per particular spec.

Battery

Type cathode absorption seal type lead-acid battery

Input voltage 2.23 V per each battery cell

Efficiency not less than 80% overall

Control voltage

Control circuit DC 100 V or AC 100 V

Inboard lighting and socket outlet AC 240 V

Control unit

LCD touch screen to be mounted as an interface Connection with

DCS through Profibus, Modbus or other open fieldbus

Accessories

Door key	1 set
Inboard lighting	1 set
Lighting door switch	1 set
Water cooling unit, if necessary	1 set
Other necessary accessories	1 set

B Spare parts for this section shall be provided for two-year operation and maintenance according to the manufacture's standard.

C Special tools for maintenance of the UPS system and the DC power supply system shall be provided according to the manufacturer's standard, if any.

1.02 Quality Assurance

A The equipment to be furnished shall be new and shall be a standard product of a manufacturer experienced in the design, fabrication and construction of UPS systems. The manufacturer shall demonstrate to the Engineer from operating installations of equal or larger capacity utilizing equipment such as herein, that all the features and appurtenances of the equipment will operated satisfactorily for the purposes intended. All equipment furnished under this Section shall be demonstrated to the satisfaction of the Engineer that the quality is acceptable.

B The Tenderer shall submit a list of customers to whom this equipment has been supplied, with dates and value of contract.

Part 2 Products

2.01 Battery Power Supplies

A Battery power supplies shall be suitable for operation with the battery system and voltage specified. The battery charger assembly shall be solid state constant potential incorporating a self protecting current limiting feature for protection against low battery voltage short circuit or reverse polarity connection to the batteries.

B The charger shall have controls for:

1 on/off

2 float/boost

charge and

indication of:

3 automatic high rate charge

4 rectifier failure

5 high dc voltage

6 low dc voltage

7 battery voltage

8 output current.

C Volt-free contacts shall be provided for remote signaling of common alarm.

D The charger shall incorporate an automatic high rate charge circuit to be initiated manually or by operation of the rectifier current limit for a period of time. This shall automatically bring the battery system, over a site adjustable time period, to float charge level.

E Batteries shall be cathode absorption seal type or nickel cadmium type designed, constructed and tested in accordance with IEC 623.

F Batteries shall be contained within translucent impact resistant flame retardant polypropylene cases. They shall be designed for low maintenance and shall have a life in service of at least 20 years.

G The batteries shall be suitable for use on switchgear and circuit protection applications.

H Batteries shall be housed within the battery charger enclosure or within a separate battery enclosure. The cells shall be arranged in tiers to enable a rapid visual check of electrolyte level and access for maintenance. Terminals shall be shrouded to prevent accidental contact. The battery enclosure shall be corrosion resistant and ventilated to prevent the buildup of gases.

I The battery installation shall be supplied complete with all tools etc necessary for the safe and efficient maintenance of the batteries.

J Warning notices shall be provided for wall mounting to warn of the presence of charge gases.

2.02 Un-interruptible Power Supply (UPS)

A The UPS shall be floor mounted, self contained and metal clad and shall be suitable for supplying a non linear load. It shall be possible to open the enclosure front door when the unit is in use without exposing any live contact to touch.

B The UPS shall be an on-line type incorporating a six pulse rectifier and pulse width modulation inverter technology with microprocessor control. It shall incorporate a static bypass switch which shall operate in the event of UPS failure, overload or manual initiation in order to transfer the output supply to mains without disturbance to the output supply. The UPS shall incorporate a dc under voltage trip circuit to electronically trip the UPS output in order to protect the batteries.

C The noise level of the unit shall not exceed 60dB(A) at 1 m from the UPS cabinet.

D The output of the inverter shall be a sine wave having less than 2 percent THD for linear loads and less than 4 percent for 50 percent non linear load. It shall be suitable for load power factors 0.7 lag to 0.9 load.

E The unit shall have a dynamic response such that a 100 percent step load causes an output voltage transient of less than ± 4 percent with a recovery time of less than 4 ms.

F For three phase output units the output voltage shall not vary by more than ± 1 percent for an unbalance of 10 percent.

G The load crest factor shall not be less than 3:1.

H The efficiency at full load and 0.8 power factor shall be greater than 88 percent.

I The unit shall incorporate a monitoring and diagnostics system to provide an audible alarm to provide warnings and fault indication.

J The following parameters shall be monitored:

1 inverter output voltage

2 battery voltage

3 static bypass voltage

4 output current

5 inverter output frequency

6 available battery bridging time at rated load

7 available battery bridging time depending on actual load. K

Indicators to indicate:

1 UPS status

2 UPS alarm conditions

L It shall be possible for operations and maintenance personnel to determine the cause of UPS failure by viewing a fault annunciation display or by interrogation of a 'user friendly' integral key pad and display unit.

M The UPS shall have an emergency power off facility. This shall be operable both locally and remotely. A 24 V dc emergency shutdown relay shall be provided to accept the remote shut down signal.

N The UPS shall be required to be manually reset after operation of the emergency shutdown.

O The UPS shall provide a volt free contact output to indicate:

1 warning, ie low battery capacity

2 fault

3 static bypass in use.

P The UPS shall have an overload capacity of 150 percent for 30 seconds and shall be protected in the event of a short circuit of the output.

Q The radio interference level shall be equal to or better than suppression degree 'N' as defined in VDE0875.

R The batteries shall be housed, either within the UPS enclosure or within a separate matching battery cubicle suitable for location adjacent to the UPS.

S The batteries shall be of the maintenance free sealed for life lead acid type.

T Batteries shall be contained within translucent impact resistant flame retardant polypropylene cases. They shall be designed for low maintenance and shall have a life in service of at least 10 years.

U The cells shall be arranged in tiers to enable a rapid visual check of electrolyte levels and access for maintenance. Terminals shall be shrouded to prevent accidental contact. The battery enclosure shall be corrosion resistant and ventilated to prevent the buildup of gases.

V The battery installation shall be supplied complete with all tools etc necessary for the safe and efficient maintenance of the batteries.

W Warning notices shall be provided for wall mounting to warn of the presence of charge gases.

X The battery supply to the UPS shall be via a fused load break switch disconnecter circuit breaker.

Y The battery recharge time to 90 percent of full charge shall be approximately ten times the discharge time at full load.

3. Technical specification for <u>UPS AND BATTERY CHARGER FOR TIC:-</u>

Design, supply, install, test and commission of new redundant UPS with redundant battery for feeding powers to the field instruments, DCS equipemtns, video surveillance system, Instruments and control panels and field instruments. All the alarms and monitoring parameters shall be interfaced via. Serial communication to the DCS. The system shall be designed base on dual power source supplied from two different UPS's hence fault tolerant design. The system shall be capable to withstand rates of noises, surges, static discharge and electrical interference complying to relevant IEC codes in same respect.

3.1 GENERAL:

The UPS unit shall be of redundant modular design, Industrial type with two source of incoming power feeding and; the rectifier module, the static by-pass switch and the manual by-pass switch. The inverter module shall draw power from the battery charger during normal operation or from the battery during the incoming power failure and shall supply the power to the load. The battery shall be an independent condition. The UPS shall switch from the inverter to the static by-pass in the event of overload or internal fault in order to enhance availability of power to the UPS load and it should possess manual by-pass switch for maintenance purpose. The isolation transformer shall protected with a circuit breaker housed in a matching cubicle shall provide to protect the output load from the Mains A/C input.

The UPS system and battery charger shall feed power supply to the supervisory control panel, and field instruments. The main redundant UPS shall feed the power to the main instrument DB and from main DB to

Sub-DBs. It shall be suitable for the continuous operation at full load under the given climatic and environmental conditions of Kuwait and shall be manufacture compliance with IEC 146,439, 75 deg. C Temperature. The power and capacity of the UPS system shall be selected by the contractor as per actual requirements, stage-II equipments and minimum 50% spare capacity shall be provided for future. The batteries shall be stationery, maintenance free lead and storage, sealed type with sufficient capacity to ensure a permanent position supply for a minimum of 4hours with full load.

3.2 CHARGER CHARACTERISTICS

The charger shall incorporate a SCR type rectifier and shall when started have walk-in sequence without any inrush current. It has incorporated a temperature sensor which measures the ambient temperature and adjusts the floating batteries voltage accordingly to ensure maximum battery life. The charge cycle should start in constant current charging mode and when the battery voltage has to be reached a pre-determined level it shall switch over to constant voltage charging mode.

3.3 DISPLAY OF UPS PARAMETERS

The UPS integral unit shall have built-in 8"LCD touch screen monitor to display the UPS/Battery parameters indications and alarms in mimic graphics, alarms, events, trends, etc. And all the parameters-indications and alarms shall interface with RTU system via. RS232/485 serial communication link in the future. The necessary IO mapping including bit address, alarm description, measurement range, etc.. to be provided.

The signals shall includes;

- Battery discharge DC voltage
- Battery discharge DC current
- True remaining back-up time
- Low battery voltage warning
- Available back-up time under normal operating condition with Mains 1 available.
- Re-charge DC voltage
- Mains frequency
- Output frequency
- Mains 1 voltage
- Mains 2 voltage
- Inverter voltage per phase
- Inverter current per phase
- Inverter load in KVA
- Inverter load in % of normal power

3.4 ALARM INDICATIONS

The UPS integral unit shall have built-in 8"LCD touch screen monitor to display the UPS/Battery parameters indications and alarms in mimic graphics, alarms, events, trends, etc.

- Battery circuit open
- Battery checking
- End of battery autonomy (pre-alarm)
- End of autonomy (UPS stop)
- Overload on inverter
- Overload on static switch
- Mains 2 voltage out of tolerance
- Rectifier input voltage out of tolerance
- Charger fault
- Rectifier fault
- Inverter fault
- Communication fault
- Over temperature on rectifier module
- Over temperature on inverter module
- Battery problem
- Load protected, power supply is ok
- Load protected, minor fault
- Load protected, battery discharging
- Load on by-pass

4. BATTERY

The batteries shall be sized to ensure continuity in the supply of power to the inverter for at least 4 hours with full load. Sizing calculations shall assume an ambient temperature between 45°C. The battery manufacturer shall have its factory in Europe, Japan or USA and shall be ISO 9000 certified and must have local agent.

The battery cells shall be lead acid maintenance free valve regulated gas recombination type, explosion proof and high impact resistant ABS housing. Battery banks shall be assembled on manufacturer recommended suitable steel racks for ease of preventive maintenance and optimum ventilations.

The battery cells design lifetime shall be at least 15 years and confirmations letter from the manufacturer shall be provided.

4.1 AC Power Supplies

A ac stabilised power supplies shall be based on the ferro-resonant, saturable reactor transformer principle. They shall provide a regulated and filtered voltage power supply.

B They shall be maintenance free and have a short circuit current limit of 2 times rated current.

C Output voltage regulation shall be better than ±1 percent for steady state and ±3 percent for transient input voltage variation of ±15 percent. Harmonic distortion shall not exceed 3 percent.

D A change of supply frequency of one percent shall not produce a voltage change in excess of 1.5 percent.

4.2 DC Power Supplies

A The power supplies will operate from 230 V ac, and produce a 24 V dc output voltage at full load current.

Voltage regulation	0.02 percent for ±10 percent mains voltage variation
Load regulations	0.3 percent from zero to full load conditions
Ripple at full load	<1 mV rms
Noise	<5 mV to 10 MHz.

B The power supply shall incorporate an overvoltage protection circuit, the components of which shall be independent of the voltage regulating circuit.

C The protection circuit shall operate within 50 ms of an overvoltage occurring, and shall cause rupturing of the mains input or output fuses.

D Automatic reset of the overvoltage protection circuit is not permitted.

E For a 24 V power supply, the overvoltage tripping setting shall be 28 V.

Part 5 - Execution

5.01 Testing

A. All equipment shall be tested both at the manufacturer's works and on site.

B. Test certificates or type test certificates shall be provided for all devices.

End of Section

Government of State of Kuwait
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Section 4F .18

Technical Specification for IP Telephone system

1) Telephone PABX System,

The telephone system at Mutla High WDC and Mutla Low shall be VOIP based telephone (IP-PBX) system.

The Contractor shall supply, install, configure, the IP-PBX system covering at Mutla High and Mutla low and interface to remote control centers at E14, E15, E13, D20, D8, D14, D16, P18, RO, NRCC/CNRCC(Doha) and Shuwaikh NCC/CNCC sites networks and PSTN system.

There shall be a menu driven dial-up interface from all operator stations, to call any site, through the exchanges with telephone connection for inter-site communication. All operational requests, messages, etc. shall be logged.

Connections shall be implemented between the IP PBX's at each site and the Kuwait national PSTN system; the number of lines required shall be assessed by the Contractor through discussions with MEW regarding anticipated traffic levels at time of commissioning and traffic levels in the foreseeable future.

The IP PBX communication system shall conform to the requirements of the CCITT standard. This will be the basic design standard for the system. The Contractor must also ensure that the system is compatible with the telephone communication system of Kuwait national PSTN system.

The IP PBX system shall be able to record and register all inter-site communications. The Engineer shall approve the system of recording and registering.

The new IP PBX system should have the facility to interface with the existing PABX system available at NCC and Kuwait region.

The system shall be designed to be expandable to cover 10 other sites in the future.

1.1. Trunk interface supported
- 1.1.1. Analogue trunk lines
- 1.1.2. ISDN lines
- 1.1.3. IP trunks lines

1.2. User interface supported
- 1.2.1. Digital sets
- 1.2.2. IP phones
- 1.2.3. SIP phones
- 1.2.4. DECT phones
- 1.2.5. VoWLAN (WIFI Sets)

1.3. Futures supported
- 1.3.1. The system should be an IP-PBX
- 1.3.2. Should support up to 200 TDM/IP users
- 1.3.3. Should support up to 20 trunk lines
- 1.3.4. Support DECT for onsite mobility
- 1.3.5. Support WIFI for onsite Voice and Data mobility
- 1.3.6. Support off-site mobility with cellular client feature
- 1.3.7. To have a built-in CTI server to have call management on every users PC
- 1.3.8. Pop-up of incoming calls with caller ID on ISDN line
- 1.3.9. List of incoming/outgoing and answered/unanswered calls
- 1.3.10. Click to dial
- 1.3.11. Integration with MS outlook to dial from Outlook contacts

1.4. Support Unified Communication features.
- 1.4.1. Multiparty conference with clock to conference
- 1.4.2. Multiparty Data conferencing

1.5. Integrated Voice mail system with the following features.
- 1.5.1. Embedded voicemail for 4 ports upgradable up-to 8 ports with adding any hardware (Software upgrade only)
- 1.5.2. 8 hours of recording time expandable up-to 200 hrs
- 1.5.3. Should allow notification on mobile
- 1.5.4. To allow on-line recording of conversation
- 1.5.5. To allow remote customization

1.6. Digital / IP sets
- 1.6.1. Digital / IP sets to have large display
- 1.6.2. Digital / IP sets in medium and higher range to have built-in QWERTY key pad to have dial by name
- 1.6.3. Digital / IP sets to support up-to 40 soft keys which can be managed with contextual keys with the help on a navigator

1.7. Conference
- 1.7.1. Support multiple 3 party conference
- 1.7.2. Support meet-me conference

1.8. Music on Hold
- 1.8.1. To have option to program music of minimum 2 min
- 1.8.2. To have external music on hold interface

1.9. Auto attendant
- 1.9.1. Support the option of basic auto attendant with the option to upgrade it to multiple trees.

1.10. Networking
- 1.10.1. Support networking with other system
- 1.10.2. Support networking with other system on IP trunks

1.11. Infrastructure
- 1.11.1. Support external battery with inbuilt charger for additional power back-up for 8 hours.

1.12. Video Conferencing
- 1.12.1. The IP-PBX should have the facility for video conferencing between sites

1.13. Infrastructure
- 1.13.1. The new IP-PBX should have the facilities to interface with the existing PABX network which supporting IP.
- 1.13.2. With reference to below point (m), Complete SR site are interfaced via new fiber optic cable and cupper dedicated line. The system should have the facility for fiber interface in future.

IP TELEPHONE SYSTEM SPECIFICATIONS;

Supply, Installation and configuration of telephone system consisting of IP PBX with 4 PSTN lines of Ministry of Communication Kuwait. .

1- IP PBX with Min. 2-100 user capacity with Mini. 4 FXS/4FXO

(The qty, capacity and user license shall be as per Particular spec and BOQ)

The IP PBX should be a standalone PBX for small to medium businesses (2-50 users) and managed service providers for on-premise. The IP PBX should also work as a hybrid solution alternative (a combination of VoIP applications using legacy telecom equipment). The PBX should Compatibility with any other third party conventional VoIP systems.

At Jaber Al Ahmed Water Towers

IP PBX with min. 2-50 user capacity licence, 4 FXS/4FXO port including 4 PSTN lines from MOC Kuwait. The scope includes distributed Fiber based LANs such as Gigabit Ethernet (high quality bandwidth) to connect VoIP phones, local server (Voice mail, IVR, Conferencing), console desk, Wireless Ethernet, Firewalls, Patch cords, Convertors, Switches, and Routers/ gateways to connect Wide Area Networks (with sufficient bandwidth) via. F.O.C and MW radio to remote control centre (NCC) and interface with NR sites PBx system.

Installation, configuration of all network components consisting of PoE 24 Port switch and Cat.5 network for 20 end points in the premises. 24-Port 10/100Mbps + 2- Gigabit TP/SFP Managed PoE Switch (802.3af), network cables, etc.. should be concealed with flexible conduits and builders works as per MEW Engineer instructions.
The F.O LAN Cables to be extended to all the water towers, guard room, Diesel generator bldg.office bldg and Guard rooms, etc.. as per MEW Engineer instructions.

The system should consist of 100 telephone end points (70 desktop 2 line phones, 10 Managers (3 line or above), 1 reception phone with 1 expansion module). The end points to be located in all the water towers, guard room, all the motorised valve and flow meter chamber, Diesel generator bldg.,, network office bldg and Guard rooms, etc.. as per MEW Engineer instructions.

The system should have provision of telephone end points for of future water towers valve chambers.

The IP PBX to be easy-to-install and feature-rich without the expense of a traditional system. The IP PBX should function not only as a PBX, but also as a voice mail server, an IVR server, a conferencing server as well as a VoIP gateway.

The IP PBX should support Min. 4 Trunk and 4 Station (4 FXO / 4 FXS).

- Complete Server as per manufacturer std. with license
- Built-in Router Ideal for Small Offices
- Up to Eight Analog Ports
- Support for a Combination of FXO and FXS Modules
- 1GB Compact Flash® Card
- Hardware-based Echo Cancellation
- 8 MB Onboard Flash
- 64 MB Onboard RAM
- 5 Ethernet Ports (4 LAN, 1 WAN)

Minimum Features of Software : The PBX software should support minimum below given features :

- Full PBX Capability
- Switched or Packet Data
- VoIP Capability
- TDM Capability
- Converged Telephony (VoIP <-> TDM)
- Voice Mail
- Unlimited-Seat Conference Bridge
- Proven Reliability Through Regression Testing
- Automated attendant.
- Distinctive ring tones.
- Call forward options
- Do not disturb.
- Call parking and retrieval.
- Multiple line appearances.
- Call pickup.
- Music on hold options.
- Call transfer options
- Music on transfer options
- Call waiting.
- Mute.
- Caller ID options.
- Unlimited conference rooms.
- Conference bridging.
- User authentication.
- Dial
- Volume control.

Voice Mail

IP PBX software should provide business with important voice mail capabilities:

- Unlimited password-protected voicemail boxes, each containing mailbox folders for organizing

- voicemail.
- Set different greetings when you are busy or otherwise unavailable.
- Default and custom announcements to greet callers leaving messages.
- Associate telephones with more than one mailbox, and mailboxes with more than one telephone.
- Send an email notification of the arrival of new voicemail with the voicemail optionally attached.
- Forward and broadcast voicemails to individual extensions or to voicemail groups.
- Provide users with a company directory of employees based on voicemail boxes.
- Create voicemail zones and groups so specific notifications can be quickly carried out.

2- <u>Small Cabin/ Desk top Phone Specifications.</u>

Lines (Directory Numbers)
- Up to 2 lines with up to 2 calls per line

Display
- Minimum 102 x 33 pixel graphical LCD

Feature Keys
- 3 context-sensitive “soft” keys
- 2 line keys with bi-colour (red/green) LED
- 2 feature keys (“Menu” and “Dial”)
- 4-way navigation key cluster with centre “Select” key
- 2 volume control keys
- Dedicated hold key
- Dedicated headset key
- Dedicated hands-free speakerphone key
- Dedicated microphone mute key
- Headset compatibility
- Dedicated 2.5-mm headset port compatible with most monaural mobile phone headsets

Hearing aid compatibility
- Compliant with ADA Section 508 Recommendations: Subpart B 1194.23 (all)
- Hearing aid compatible (HAC) handset for magnetic coupling to approved HAC hearing aids
- Compatible with commercially-available TTY adapter equipment

Audio Features
- Full-duplex hands-free speakerphone with Acoustic Clarity
- Type 1 compliant with IEEE 1329 full duplex standards
- Frequency response - 300 Hz - 3300 Hz for handset, headset and hands-free speaker phone modes
- Codecs: G.711 μ/A and G.729A (Annex B)
- Individual volume settings with visual feedback for each audio path
- Voice activity detection
- Comfort noise fill
- DTMF tone generation / DTMF event RTP payload
- Low-delay audio packet transmission
- Adaptive jitter buffers
- Packet loss concealment
- Acoustic echo cancellation
- Background noise suppression

Call handling features
- Shared call / bridged line appearance
- Flexible line appearance (one or more line keys
- can be assigned for each line extension)
- Distinctive incoming call treatment / call waiting
- Call timer

- Call transfer, hold, divert (forward), pickup
- Called, calling, connected party information
- Local three-way conferencing
- One-touch speed dial, redial
- Call waiting
- Remote missed call notification
- Intercom
- Automatic off-hook call placement
- Do not disturb function

Other Features

- Interoperability with Microsoft LCS 2005 for telephony and presence3
- -- Compatibility with Microsoft Office Communicator and Windows® Messenger 5.1 Clients
- Enabled for Industry Standard Productivity Suites
- Local feature-rich GUI
- Time and date display
- User-configurable contact directory and call history (missed, placed and received)
- Wave file support for call progress tones
- Unicode UTF-8 character support. Multilingual user interface

Protocol Support

- IETF SIP (RFC 3261 and companion RFCs) Network and provisioning
- Two-port 10/100 Mbps Ethernet switch
- Manual or dynamic host configuration protocol (DHCP) network setup
- Time and date synchronisation using SNTP
- FTP / TFTP / HTTP / HTTPS server-based central
- provisioning for mass deployments
- Provisioning and call server redundancy supported
- Web portal for individual unit configuration
- QoS Support – IEEE 802.1p/Q tagging (VLAN), Layer 3
- TOS and DSCP
- Network Address Translation (NAT) support for static configuration and “Keep-Alive” SI signalling
- RTCP support (RFC 1889)
- Event logging
- Syslog
- Local digit map
- Hardware diagnostics
- Status and statistics reporting Security1
- Transport Layer Security (TLS)
- Encrypted configuration files
- Digest authentication
- Password login
- Support for URL syntax with password for boot server
- HTTPS secure provisioning
- Support for signed software executables
- Power
- Built-in, auto-sensing IEEE 802.3af Power over Ethernet (Class 1)
- External universal input AC adapter (optional4;24V DC @ 500mA)

Approvals

- FCC Part 15 (CFR 47) Class B
- ICES-003 Class B
- EN55022 Class B
- CISPR22 Class B
- AS/NZS CISPR 22 Class
- VCCI Class B
- EN55024 Class B
- EN61000-3-2; EN61000-3-3; EN-61000-6-1
- ROHS compliant

- Anatel
- GOST
- C-Tick
- CCC

Safety
- CE Mark
- EN 60950-1
- IEC 60950-1
- NRTL
- CAB/CSA-C22.2 No. 60950-1-03
- AS/NZS 60950-1

Operating Conditions
- Temperature: +10 to 40°C (+50 to 104°F)
- Relative humidity: 20% to 85%, non-condensing
- Storage Temperature
- -40 to +70°C (-40 to +160°F)

Physical Details: Console
- Handset with handset cord
- Base stand
- Network (LAN) cable
- Quick start guide
- Product registration card

3- Manager Phones with 3 lines .

Display
- 144 x 128 pixel graphical LCD
- Message waiting indicator

Keys
- 2 line keys with bi-color LEDs
- 9 dedicated keys
  - 2 volume control keys
  - 3 feature keys
  - Mute key
  - Headset key
  - Hands-free speakerphone key
  - Hold key
- 4 context-sensitive soft keys
- 5 display control keys

Power
- Integrated IEEE 802.3af Power over Ethernet support
- External universal AC adapter (included, 24V DC)
- Power consumption: 3.0W nominal (3.8W max)
- Note: Power consumption indicated may be exceeded under start-up conditions. Customers should always use the original power source supplied with the phone

Headset Capability
- Amplified headsets with an RJ-9 jack are recommended
- Hearing Aid Compatible (HAC) in accordance • with Section 508 Standards for Electronic and Information Technology, Telecommunication Products (1194.23)

Audio

- Full-duplex speakerphone with Acoustic Clarity Technology
- Headset, handset, and hands-free modes
- Local 3-way conferencing
- Individual volume settings with visual feedback for each audio path
- Customizable audio sound effects
- Support for G.711 μ/A and G.729A (Annex B) codecs
- Adaptive jitter buffers and packet loss concealment algorithms
- Acoustic echo cancellation
- Voice activity detection and comfort noise fill
- Telephony Tone Signaling (RFC2833)
- Record and playback for diagnostic purposes

Call Handling Features

- Shared call/bridged line appearance
- Flexible line appearance (one or more line keys can be assigned for each line extension)
- Busy Lamp Field (BLF)
    - Distinctive incoming call treatment/call waiting
    - Call timer
    - Call transfer, hold, divert (forward), pickup
- Called, calling, connected party information
- Local three-way conferencing
- One-touch speed dial, redial
- Call waiting
- Remote missed call notification
- Intercom
- Automatic off-hook call placement
- Do not disturb function

Network and Provisioning

- Dual 10/100 Mbps switched Ethernet ports
- Manual or dynamic host configuration protocol (DHCP) setup
- Time and date synchronization using SNTP
- Central provisioning for mass deployments from an FTP, TFTP, HTTP, or HTTPS3 server. Provisioning server redundancy supported2
- QoS support - IEEE 802.1 p/Q tagging (VLAN), Layer 3 TOS, and DSCP2
- Network Address Translation (NAT) support
- RTCP support (RFC1889)
- Event logging
- User-selectable hardware diagnostics (Network/CPU/Memory monitoring)

Protocol Support

- IETF SIP (RFC 3261 and companion RFCs)

Security

- Transport Layer Security (TLS)
- Encrypted configuration files
- Digest authentication
- Password login
- Support for URL syntax with password for boot server3
- HTTPS secure provisioning
- Support for signed software executables

Feature Summary

- Up to 2 dedicated lines
- Local feature-rich GUI

- Shared call / bridged line appearance
- Multiple call appearances
- Flexible line appearances
- Call transfer, hold, divert (forward)
- Called, calling, connected party identification / information
- One-touch speed dial, redial
- Local 3-way conferencing
- User configurable contact directory and call history (Missed, placed and received)
- Integration with Microsoft LCS 2005 for telephony and presence2
    - Compatibility with Microsoft Office --Communicator and Windows® Messenger 5.1 Clients
- Distinctive incoming call treatment / call waiting
- Automatic on-hook call placement ("hot-dial")
- Do Not Disturb function
- Call timer
- Multilingual user interface supporting
- Country-specific call progress tones
- Wave files support for call progress tones
- Hardware diagnostics
- Status and statistics query

Physical Features:

- 430 console
- Handset and handset cord
- Reversible desk-mount / wall-mount stand
- Network cable
- Universal power adapter (including country- specific cord kit)
- Quick Start Guide
- Product registration card

Approvals

- FCC Part 15 (CFR 47) Class B
- ICES-003 Class B
- EN55022 Class B
- CISPR22 Class B
- AS/NZS 3548 Class B
- VCCI Class B
- EN55024
- EN61000-3-2; EN61000-3-3, EN61000-6-1
- ROHS compliant

Safety

- UL 60950
- CE Mark
- CAN/CSA C22.2 No. 60950
- EN 60950
- EN61000-4-2

EN61000-4-4

- EN61000-4-11
- IEC 60950
- AS/NZS 3260

Operating Conditions

- Temperature: +10 to +40 degrees C (+50 to +104 degrees F)
- Relative humidity: 20%-85% (noncondensing)
- Storage Temperature
- -40 to +70 degrees C (-40 to +160 degrees F)

4- Color Attendant Console (6 line)

Lines (Direct Numbers)

- Up to six lines (standalone mode)
- (Expandable capability Up to 34 lines with Color Expansion Module(s)

Color Expansion Module Support

- The PoE version supports one Color Expansion Module
- The PSU version supports up to three Color Expansion Modules

Display

- 320 x 160 backlit color graphical LCD
- LED backlight with custom variable intensity control

Feature Keys

- 4 context-sensitive “soft” keys
- 26 dedicated “hard” keys

--6 line keys with bi-color (red/green) LED
--8 feature keys
--6 display/menu navigation keys
--2 volume control keys
--Illuminated mute key
--Illuminated headset key
--Illuminated hands-free speakerphone key
--Dedicated hold key

Headset and Hearing Aid Compatibility

- Dedicated RJ-9 headset port

--Amplified headsets are recommended

- Compliant with ADA Section 508 Recommendations: Subpart B 1194.23 (all)
- Hearing Aid Compatible (HAC) handset for magnetic coupling to approved HAC hearing aids
- Compatibility with commercially-available TTY adapter equipment

Audio Features

- HD Voice technology delivers life-like voice quality for each audio path - the handset, the hands-free speakerphone, and the headset1
- Full-duplex hands-free speakerphone

--Type 1 compliant with IEEE 1329 full duplex standards

Frequency response - 150Hz - 7kHz for handset, headset1 and hands-free speakerphone modes

- Codecs: G.722 (wideband), G.711 μ/A, and G.729A (Annex B)
- Individual volume settings with visual feedback for each audio path
- Voice activity detection
- Comfort noise fill
- DTMF tone generation/DTMF event RTP payload
- Low-delay audio packet transmission
- Adaptive jitter buffers
- Packet loss concealment
- Acoustic echo cancellation
- Background noise suppression

Call Handling Features

- Shared call/bridged line appearance
- Flexible line appearance (one or more line keys can be assigned for each line extension)
- Busy Lamp Field (BLF)
- Distinctive incoming call treatment/call waiting
- Call timer
- Call transfer, hold, divert (forward), pickup
- Called, calling, connected party information
- Local three-way conferencing
- One-touch speed dial, redial
- Call waiting
- Remote missed call notification
- Intercom
- Automatic off-hook call placement
- Do not disturb function

Other Features

- Enabled for the Productivity Suite
- Integration with Microsoft LCS 2005 for telephone and presence
  --Compatibility with Microsoft Office Communicator and Windows® Messenger 5.1 Clients
- Universal Serial Bus (USB)
  --Full Host Controller
  --Compliant with OHCI 1.1 specification
  --Support for Full-speed and Low-speed peripherals
  --Type-A receptacle interface
- Local feature-rich GUI
- Time and date display
- User-configurable contact directory and call history (missed, placed, and received)
- Customizable call progress tones
- Wave file support for call progress tones
- Unicode UTF-8 character support. Multilingual user interface encompassing

Protocol Support

- IETF SIP (RFC 3261 and companion RFCs)

Network and Provisioning

- Two-port Gigabit Ethernet switch:
  --10/100/1000Base-Tx across LAN and PC ports
  --Conformant to IEEE802.3-2005 (Clause 40) for Physical Media Attachment
  --Conformant to IEEE802.3-2002 (Clause 28) for Link

Partner Auto-Negotiation

- Manual or dynamic host configuration protocol (DHCP) network setup
- Time and date synchronization using SNTP
- FTP/TFTP/HTTP/HTTPS4 server-based central provisioning for mass deployments. Provisioning server redundancy supported
- Web portal for individual unit configuration
- QoS Support – IEEE 802.1p/Q tagging (VLAN), Layer 3 TOS, and DSCP
- Network Address Translation (NAT) support – static
- RTCP support (RFC 1889)
- Event logging
- Local digit map
- Hardware diagnostics
- Status and statistics

Security

- Transport Layer Security (TLS)

- Encrypted configuration files
- Digest authentication
- Password login
- Support for URL syntax with password for boot server
- HTTPS secure provisioning4
- Support for signed software executables

Power
- Built-in, auto-sensing IEEE 802.3af Power over Ethernet
- External Universal AC adapter (included 48V DC)

Approvals
- FCC Part 15 (CFR 47) Class B
- ICES-003 Class B
- EN55022 Class B
- CISPR22 Class B
- AS/NZS CISPR 22 Class B
- VCCI Class B
- EN55024
- EN61000-3-2; EN61000-3-3
- ROHS compliant
- Safety
- UL 60950
- CE Mark
- CAN/CSA-C22.2 No. 60950
- EN 60950-1
- IEC 60950-1
- AS/NZS 60950

Operating Conditions
- Temperature: 0 to 40°C (+32 to 104°F)
- Relative humidity: 5% to 95% (noncondensing)

Storage Temperature
- -40 to +70 degrees C (-40 to +160 degrees F)

Physical Detials:
- 670 console
- Handset with handset cord
- Base stand
- Network (LAN) cable
- Universal power adapter (including country-specific cord kit)

5- EXPANSION MODULE for Attendant Console.

Display
- Min. 160 x 320 pixel colour graphical LCD

Feature Keys
- 14 multifunctional line keys automatically configurable as a line registration, call appearance, speed dial, DSS, or BLF key1
- Dual-colour (red or green) illuminated LEDs for line status information

Protocol Support

- IETF SIP (see the 670 data sheet for details)

Compatible Model

- Should be Compatible with Main Attendant Phone

Connection with the Host Phone

- IrDA Protocol
- - Compliant to Serial Infrared
- Physical Layer Link SIR data rate (115.2kbits/s)
- - Activated upon attachment to host

Power

- The Colour Expansion
- Module is powered by the host phone
- - Host phone powering options: IEEE
- 802.3af PoE or through an external
- AC adapter (48V DC)
- Powering starts automatically upon connection
- If powering more than one Colour Expansion module, an external AC adapter is required

Expandability

- Up to three Colour Expansion Modules can be attached to the host 670 phone to provide a high-performance attendant console with 48 multifunctional line keys and four high-resolution colour displays

Feature Support

- Local feature-rich GUI with animation
- Shared call appearance, bridged line appearance (Key System emulation)
- Multiple call appearances
- Flexible line appearance (requires SIP 3.0.2 RevB or higher)
- Multilingual user interface (driven from the host 670 phone)

Approvals

- EMI/EMC Approvals under the host
- 670 phone

Safety

- UL 1950
- CE Mark
- CSA C22.2 No.950
- EN60950.1

Operating Temperature

- +10 to +40 degrees C (+50 to +104 degrees F)

Relative Humidity

- 20% to 85%, non-condensing

Storage Temperature

- -40 to +70 degrees C (-40 to +160 degrees F)

Physical Features:

- Colour Expansion Module console
- Colour Expansion Module base stand

7. IP PBX Network Infrastructure :

IP PBX with min. 2-200 user capacity licence, 4 FXS/4FXO port including 4 PSTN lines from MOC Kuwait. The scope includes distributed Fiber based LANs such as Gigabit Ethernet (high quality bandwidth) to connect VoIP phones, local server (Voice mail, IVR, Conferencing), console desk, Wireless Ethernet, Firewalls, Patch cords, Convertors, Switches, and Routers/ gateways to connect Wide Area Networks (with sufficient bandwidth) via. F.O.C and MW radio to remote control centre (NCC) and interface with NR sites PBx system.

Installation, configuration of all network components consisting of PoE 24 Port switch and Cat.5 network for 20 end points in the premises. 24-Port 10/100Mbps + 2- Gigabit TP/SFP Managed PoE Switch (802.3af), network cables, etc.. should be concealed with flexible conduits and builders works as per MEW Engineer instructions. The F.O LAN Cables to be extended to LCC, S/Stn. F.W/B.W Pumping stn. D/G bldg, radio room, chemical Bldg, network office bldg and Guard rooms, etc.. as per MEW Engineer instructions.

The system should consist of 100 telephone end points (70 desktop 2 line phones, 10 Managers (3 line or above), 1 reception phone with 1 expansion module). The end points to be located as per MEW Engineer instructions.

8. Telephone Hotline System

A telephone hotline shall be provided between MH WDC and Water Towers (D14,D16,D20,D8), P18, E15, RO, Doha NRCC and NCC. The new system shall be interfaced with the existing system at NCC and the existing hot line telephone system covering Kuwait Region. The hotline telephone shall provide conference call connections to all connected lines. Ringing shall be automatic upon pickup of any connected line. This system shall communicate over the telecommunication network via network interface nodes. The system shall be expandable to cover 10 others sites in the future.

Government of State of Kuwait
Ministry of Electricity and Water

Section 4F.19

Technical Specification for Microwave Radio system and associated software.

MicrowaveRadioSystem

Design, Supply, shipping, transport to site, Install, Cabling, Configure, IFAT, test and commission of failsafe fault tolerant DCS, Telecommunication, Video surveillance, VoIP telephone, between Water Towers (D20, D8, D14), Pumping stations (P18, E20) and Storage Reservoir (E15) to Mutla High (E14) and Doha NRCC (Northern Region control centre) and NCC National Control Centre at Shuwaikh, as per the communication system layout.

Site Survey, Engineering, Supply, transport to site, Installation, Cabling, Configuration, integrated factory acceptance test (IFAT), commissioning, SAT, training, maintenance and guarantee of Telecommunication System between the following sites local control centre's and to remote control centre.

Si no	From	To	Communication tower
1	Mutla High WDC (E14)	Subiya (E20) WDC	At MH WDC, New communication Tower. At Subiya WDC, the existing shall be re-utilized including required modifications to install new Dis antennas.
2	Mutla High WDC(E14)	Jahara Water (D20) Towers	New MWR Tower shall be installed on the roof of th existing water (D20)towers
3	Mutla High WDC(E14)	Jahara Water (D8) Towers	New MWR Tower shall be installed on the roof of th existing water (D8)towers
4	Mutla High WDC(E14)	Saad Al-Abdullah D14 Wate Towers	New MWR Tower shall be installed on the roof of th existing water (D14) towers
5	Mutla High WDC(E14)	Jahara (P18) Pumping station	At P18 stn, the existing water network dep communication tower shall be re-utilized, wit required modifications to install new Dish antennas.
6	Mutla High WDC(E14)	Mutla Low (E15) WDC	At **E14 and E15** WDC shall be New MW Radi communication Tower.
7	Mutla High WDC(E14)	Doha NRCC	**At Doha WDC**, the new tower will be installed unde D22 Towers contract, it shall be re-utilized, includin required modifications to install new Dish antennas.
8	Mutla High WDC(E14)	Shuwaikh Via. WF WDC	**At NCC shuwakh**, the new tower will be installe under MA WDC.II contract, it shall be re-utilized including required modifications to install new Dis antennas.
9	Jaleeb Al Shoukh WT(D16)	West Funitees (E13) WDC	New MWR Tower shall be installed on the roof of th existing water towers
1	Subiya WDC (E20)	NCC (Shuwikh)	**At WF WDC**, the new tower will be installed unde MA WDC.II contract, it shall be re-utilized, includin required modifications to install new Dish antennas.
1	Doha NRCC	NCC (Shuwaikh)	

the scope includes site survey and study of M.W Radio signal Propagation including Multi Path availability calculations, reflection analyses, frequency interference, antenna gains etc., to make as a failesafe and fault tolerant ring/mesh network topology between the sites.

Microwave radio system including space diversity with Parabola Dish antenna (ODU), MW Radio equipments (IDU), router, modems, managed Ethernet network switches, cabinets, surge protector, connectors, fibre optic cables, lightening protection and aviation lights with required mounting accessories, to transfer the DCS data, VoIP, Video surveillance system between sites and NRCC and NCC as a failsafe fault tolerant ring network and interface with local DCS system via. dual F.O. LAN. The MW Radio equipments measurement and fault diagnosis alarm signals to be hardwired/interface with DCS system.

The scope of work includes site survey, radio propagation study, supply, furnishing and installing in places at the locations stated, the microwave radio telecommunications equipment and providing miscellaneous materials and services complete as specified herein.

Site survey and study of M.W Radio signal Propagation including Multi Path availability calculations, reflection analyses, frequency interference, antenna gains etc., to determine the tower heights but not less than the height as specified in the BOQ.

The study shall includes to make the Radio WAN communication as a fault tolerant ring or mesh network topology between sites and submit the details to MEW.

The complete Survey and design calculations shall be carried out by the specialist telecommunication OEM.

The scope includes obtaining M.W frequency from MOC including three years payment for radio equipments and license.

All equipment and materials required for a complete microwave radio telecommunications system shall be furnished and completely installed. The equipment and materials to be furnished shall include, but not necessarily be limited to, the following major items:

- Microwave radios,
- Equipment racks and electronics,
- Antenna systems, including waveguides and feed assemblies,
- Equipment housings and associated air conditioning,
- Digital multiplexing, routers, gateways, switches and fibre optic cable interfacing equipment,
- Network maintenance monitoring system and interfaces to DCS system.
- All the indications and alarms to be interface and Configure into DCS system.

Unless otherwise noted, the equipment and materials furnished shall be supplied, delivered, inspected, stored, installed and tested by the Contractor.

In addition to the general Site Acceptance Tests for this Contract, the equipment may be tested by the client after installation to demonstrate its ability to operate under the conditions and fulfill the guarantees as set forth herein. If the tests indicate that the equipment fails to meet guaranteed performance, the Contractor shall make additional tests and modifications.

The Contractor shall provide drawings and other engineering data, manufacturer's field services, tools, instruction manuals, recommended spare parts list, miscellaneous materials and services and installation services and shall participate in design liaison meetings as required by MEW and the Ministry of Communications (MOC).

MicrowaveRadio

1) System Purpose
The microwave radio telecommunications system equipment shall be furnished and installed for the purpose of providing transport of voice, Distributed Control System (DCS) data and data communications channels.

2) System Configuration, Locations and Quantities
The microwave digital telecommunication system shall operate as defined in the particular specification requirements section.

3) System Performance
The reliability of the digital microwave equipment shall be based on the Mean Time Between Failure (MTBF) rate associated with each major equipment item. Equipment shall have, as a minimum, the following MTBF rates: 100, 0000 hours.

4) Radio Frequencies
The Contractor shall undertake a frequency search and frequency plan the frequency selection should be in the range between 7~13 Ghz. (as per availability and approved from MOC)

5) Performance Requirements

The Contractor shall be responsible for the overall performance of the microwave radio system. The Contractor shall obtain maps and verify that the Contractor has all pertinent information about the sites and area. Radio propagation attenuation losses, antenna gains and heights, availability and reliability shall be calculated by the Contractor, this shall take the form of a desktop study supplemented by a site survey using instrumentation. Documentation of calculations shall include all parameters specified as follows:

- Antenna Diameter/ Model — Antenna Centre Line (m)
- Antenna Gain (dBi) — Antenna Radom Loss (dB)
- Transmission Line Type — Transmission Line Length (m)
- Transmission Line Loss (dB) — Connector Jumper cable loss (dB)
- Frequency (MHz) — Path Length (km)
- Free Space Path Loss (dBi) — Field Margin (dB) (1 dB)
- Diffraction Loss (dB) — Atmospheric Absorption Loss (dB)
- Equipment Type /Model :-
- Transmit Power (dBm)
- Receive Threshold Level for 10E-6 bit error rate (dBm)
- Dispersive Fade Margin (dB) — Dispersive Fade Occurrence Factor
- Climatic Factor — Terrain Factor
- Average Annual Temp (deg.C) — Path Availability two way (%)
- Rain Climate Region — Polarization
- Rainfall Rate exceeded for .01% of year (mm/hr)
- Rainfall Attenuation (dB)
- Multi-path and reflection analysis shall be included.

6) Path availability

The microwave equipment and antenna system shall provide a minimum path availability of 99.995%.The Contractor shall include a data sheet that specifies the path availability, including all gains and losses for the following:

The Contractor shall provide finalized path calculations after a path survey, including all fixed gains and losses from the items listed above, multi-path and reflection analyses. The Contractor shall not manufacture equipment until the Engineer has approved final path calculations.

The site survey to be carried out by the specialist telecommunication OEM, in presence of MEW Engineer.

7) Path Loss

Station-to-station measured path loss shall be demonstrated within 3 dB of the calculated loss. The following information shall be recorded to verify measured net path loss:

- Transmitter output power.
- Receiver carrier power.
- Net path loss.

Substitution techniques or calibrated AGC curves, unique for each radio provided, shall be used to measure the received carrier power level.

8) Digital Microwave Radio Equipment

Digital microwave radio equipment furnished under these specifications shall be entirely solid state. The minimum receiver sensitivity of the system shall be -80 dBm without antenna.

9) Transmitter

Each transmitter shall have the following minimum characteristics, except as noted elsewhere within these specifications.

- Output impedance 50 ohms
- Antenna connection fiber

- Spurious radiation — In accordance with FCC mask for digital microwave transmitters
- Stability — +/- .002 percent
- Duty cycle — Continuous
- Modulation — As required to fit within the bandwidth
- Mounting — Rack mounted

10) Receiver

Each receiver shall have the following minimum characteristics, except as noted elsewhere within these specifications.

- Input impedance — 50 ohms
- Antenna connection — fiber
- Stability — +/- .002 percent
- Modulation — As required to fit within the bandwidth
- Mounting — Rack mounted

11) Monitoring of the Microwave Radio System

In the event of a receiver failure or excessive BER (1x10-3), the affected receiver shall be separated from the digital baseband output and shall not add noise or error bits.

12) Indicators and alarms

Meters and test points shall be included as an integral part of the equipment at each station to measure all currents and voltages essential to normal system adjustment of the RF and power equipment. Meters may be provided through the radio maintenance interface.

- Panel mounted alarm indicators and contacts (normally closed fail-safe) shall be provided.
- The following alarms shall be provided as a minimum.
- Major Alarms:-
- Transmit Local Oscillator Alarm — RF Low Power Alarm
- Far End Receive Failure — Demodulator Equipment Alarm
- Receive Degraded Alarm — Common or PA Power Supply Alarm
- Receiver failure — BER greater than or equal to 10-3
- Minor Alarms:-
- Transmit Summary Alarm — Automatic Power Control High Power Alarm
- Transmit Path On Line — Tributary Receive Alarm Indication Signal
- Switch OFF/NORMAL — Receive Combined Alarm
- Radio Frame Alarm — Receive Alarm Indication Signal
- Receive Path On Line — Common Loss Alarm
- SYNC Alarm — Automatic Power Control Locked high
- Automatic Power Control Locked low — SYNC On-line
- Radio Command Path Fail — Radio Control Processor Controller Alarm
- Radio Control Processor Fail (Set by relay card)

It is understood that alarm configurations may vary from one manufacturer to another. Therefore, the Contractor shall submit the following information:

The Contractor shall identify which alarms, in the above lists, and those which are not shown in the above list that will be provided via external contacts. The Contractor shall identify these alarms as either major or minor alarms based on the manufacturer's equipment configuration and all the indications and alarms to be interface, configured into DCS system, including mimics, alarms, event, report printers.

13) Telecommunications System Synchronization (if it is Ethernet it is not required)

As a minimum, the radio equipment shall be capable of receiving its clocking signal from all of the following:-

- Over-the-air timing (loop timing). For this, the clock signal shall be transmitted over the fiber optic system.
- External BITS timing source.
- Internal clock to maintain hold-over synchronization upon loss of the incoming line signal. The internal clocking system shall meet or exceed Stratum 4 accuracy.

14) Optical Communications Interface Requirements

- The digital microwave radio equipment shall be provided with a direct optical signal interface. The optical interface characteristics of the equipment for the optical signal shall be as defined in ANSI T1.105 and ANSI T1.106.

- Transceiver optical fiber connectors shall be single mode SC, ST or FCPC compatible connectors. The connector loss shall not exceed 1.0 dB. The Contractor shall provide the fiber optic patch cords to connect the digital microwave radio equipment with the optical fiber communication multiplex equipment. The patch cords shall be a minimum of 3m in length.

15) Antenna Equipment

This section specifies the requirements for all microwave antenna and the radio transmission line connecting the antenna to the radio equipment.

General

The antenna locations shall be as defined in the particular specification requirements section.

Environmentalconditions

All antenna systems shall supply the specified load under the environmental conditions, specified elsewhere, without degradation or damage. Wind speeds of up to 112 km/h (70 mph) shall not result in deflection exceeding 0.1 degree of antennas (when there is no significant tower deflection of 0.1 degree).

Microwaveantenna

The antennas shall be suitable for operation within the selected range band operation and shall meet all FCC and NTIA rules and regulations. Antennas shall be high performance parabolic type. Antenna diameters shall be as indicated below.

Antenna polarization shall be as required by the NTIA.

The antenna system shall be capable of total disassembly for shipping purposes.

Each antenna shall be supplied with a heavy-duty galvanized steel mount including all mounting hardware, including pipe mounts and adjustable side and bottom struts.

The Contractor shall take special precautions to avoid intrastation interference, and antennas shall be well separated to minimize intrastation antenna couplings. Antenna shrouds shall be provided where required to minimize intrastation antenna couplings.

Each antenna shall be a high performance shielded parabolic reflector, vertical tower mount, and a low VSWR single polarized feed assembly as required to match the waveguide to the antenna.

The Contractor shall verify all paths and may propose an alternate plan(s) if the specified system solution does not meet the stated design and performance criteria.

16) Antenna Grounding

Exposed elements of the antenna system shall be grounded against lightning and electrical shock hazards. All elements shall be bonded to each other, to the supporting structures and to the ground wire running the length of the tower. Each waveguide shall be grounded near the antenna (tower top), at the base of the tower and at the building entrance. The grounding kits shall be connected to the ground wire running the length of the tower and not the structural steel. All ground wire shall be number 16mmsq or larger copper wire.

17) Drying and Pressurization Equipment

Automatic, microprocessor controlled and fully programmable drying and pressurization equipment shall be furnished to continuously supply dry air so as to maintain a constant positive pressure within the waveguide system. The system shall provide pressurization that shall not exceed the pressure rating of any antenna or waveguide

component and shall be supplied with pressure relief capabilities to prevent sudden pressure increases due to temperature changes. The system shall also maintain a relative humidity within the antenna system as per the antenna and waveguide manufacturer's recommendation. The alarm settings for the following alarms shall be fully programmable: high humidity, high and low pressure and excess run time. The system shall be lightning surge protected and equipped to function as a sound deadened unit. The system shall also contain a monitoring system that contains flow meters for each waveguide. Dry contacts shall be provided for each alarm and shall be rated, as a minimum, 1A at 240 VAC.

18) Accessories

Cable Hangars

All cable hangars shall be stainless steel. Angle adapters shall be used on towers and angle structures. Cable hangars shall be provided complete with attachment hardware.

Hoisting Grips

Hoisting grips shall be designed for permanent attachment to cables. Each grip shall be designed specifically for the diameter of cable to be used.

Grounding Kits

Grounding kits for waveguide shall be solid copper construction. Each kit shall include tower attachment hardware, ground terminal, ground wire, ground strap with flange, electrical tape and a coiling tool.

Connectors

Connectors shall be corrosion resistant and weatherproof. "O" ring seals shall be part of each connector. Connectors shall have a high level of RF shielding.

Tool Kits

Flaring and bending tool kits shall be provided in the quantities that are necessary for the Contractor's installation of elliptical waveguide. The tool kits shall be specially designed for the type of elliptical waveguide to be provided.

An additional, unused set of flaring and bending tools shall be provided.

19) Special Factory Testing Requirements

All radio equipment (excluding antenna system) shall be tested for a minimum of seventy-two (72) continuous hours under power prior to shipment from the factory. For the last sixteen (16) hours of testing, the ambient temperature shall be elevated to 50degC. The equipment shall be interconnected with devices which shall cause it to repeatedly perform all operations it shall be expected to perform in service with loads on the various components equivalent to those which shall be experience in actual service. The seventy-two (72) hours of factory burn-in can include the hours spent performing the factory acceptance test.

20) Special Site Testing Requirements

Initial check out

The Contractor shall furnish experienced personnel and all equipment and apparatus necessary for adjustment and testing of all radio equipment. If during the testing, the Engineer believes that the Contractor is not performing the test properly, or if there are questions concerning whether the equipment is operating within parameter, the Engineer has the right to require the Contractor to change his test, perform another test, or re-test in order to resolve the problem. The Contractor shall provide the Engineer with five copies of all field test results. The Contractor's responsibility for checkout, field tests, and adjustments shall include the following:-

- Frequency measurement
- Received signal level measurement
- Occupied RF band width measurement
- VSWR on all RF transmission lines connected to antenna
- Final antenna alignment
- DC power supply measurement
- Bit error rate measurement
- Optical interface measurement (bit error rate, signal levels, optical power and sensitivity)
- Microwave radio alarm tests (verify that alarm conditions initiate alarm indications and contact closures)

- Fail-over tests for power supplies, transmitters, and receivers
- Digital interface measurement (bit error rate, waveform observation, signal levels)
- Other tests recommended by the Contractor or requested by the client

21) Network Telecommunication Management system

The Contractor shall supply, configure and install a fully functioning telecommunications between local control centre's and remote control centre. This system shall as a minimum include a monitor screen, keyboard and printer this equipment is subject to Engineer approval. The NCC shall be capable of configuring the network, monitoring and managing its operation, detecting and diagnosing failures and printing configuration and statistical reports. User access to the telecommunications network control centre shall be password protected.

The NCC shall present the system manager with a diagrammatical representation of the telecommunications network. The system manager shall be able to obtain information and modify the configuration using graphical or menu driven methods.

The Network Telecommunication Management system shall exchange the status of the communication links (fibre optic cables and radio links) and its failure alarms, location of cable fault alarms to be configured into DCS system.

22) Master Station Software:-

General Requirements

The Contractor shall provide all software and licences, fully configured to accomplish the requirements of the Specification, including any supporting or configuration software used to generate the system.

All software shall be standard, fully, debugged programs currently in use by the system supplier on similar systems. All software shall be of the most recent version and revision available at the completion of the Contract unless otherwise agreed by the Engineer. All software shall be fully maintained by the Contractor throughout the contract and warranty periods.

System Security

The system shall be protected from unauthorised changes to the operating system and application programs.
The system shall prevent unauthorised users from rebooting the system or aborting or suspending system-related programs.

Signal Processing

The system shall continuously receive data from the field devices, unless otherwise specified, such that a 'significant' change in local field conditions shall be detected processed and displayed by the system in less than 3 milli seconds. A 'significant' change in field conditions at a site remote from the system shall be processed and displayed by the system in less than 3 milli seconds after detection. A 'significant' change is defined to mean any change of state of a discrete point or any change of an analogue point outside a definable dead band.

A report by exception method for acquiring field data is acceptable. However, in this case, no change of an analogue variable outside a dead band, in percent of full span, shall go undetected by the system, and a full scan of each field device shall take place at least every 3 m/s.

Time synchronization in all integrated systems between local DCSs to the NCC shuwaikh (from local area network to wide – area network) via. fiber optic and Radio system, to be accurately synchronized and real time updating within +/- 1ms for the same domain or +/-3 ms for different domain.

Alarm Processing

The system shall process alarm conditions in the form of process abnormalities, field device failures, sequence faults, DCS system component malfunction and other configurable events. Alarm processing and display shall comply with the following as a minimum:-

(a) All alarms detected by a field device shall be time stamped (i.e. date and time of occurrence) at DCS level. (b)

An alarm acknowledgement function shall be provided. Acknowledged alarms where field conditions revert to normal shall clear. Unacknowledged alarms where field conditions revert to normal shall not clear until acknowledged. Alarm conditions which clear shall generate a log entry.

(c) Each new alarm condition shall activate an audible alarm and generate an alarm log entry as specified in the

clause entitled Alarm and Event Logging.

(d) Any alarm condition shall be designated as such on any dynamic display which depicts the process involved. Unacknowledged alarms shall be distinguishable from acknowledged alarms. Symbols for discrete alarm conditions shall change colour and/or the symbol itself shall change when an alarm condition is present.

(e) The system shall allow an authorised user to inhibit alarm processing for any desired analogue, discrete or calculated point.

(f) Limit alarms shall be definable for all analogue points for over range, extra high alarm, high alarm, low alarm, extra low alarm and under range.

(g) A delay-before-alarm interval shall be definable for each analogue point such that an alarm condition is not registered until the current value remains outside alarm limits for a period of time exceeding the interval. Each discrete point designated as an alarm shall have a definable delay-before-alarm interval.

(k) A change of state of a discrete point shall be definable as an alarm, a logged condition or information only. A change of state of a point designated as a logged condition shall generate a log entry but not an alarm event.

(l) Control alarms shall be generated whenever control actions are attempted by the system and no status is received by the system indicating that the requested action has taken place.

(m) The occurrence of an alarm shall be definable as an event which can be used by the system to trigger subsequent definable actions.

(n) Alarm processing shall be provided which reduces the over saturation of the alarm display and summary facilities upon the occurrence of multiple alarm conditions (particularly as a result of mains failure, or burst main conditions).

(o) The continuous alarm generation or retrieval of alarms at workstations shall not decrease the communication throughput of either the 'process' LAN or the 'system' LAN.

Alarm, Event Logging

The system shall provide for the generation of a log of events detected by the system. Events to be logged shall minimally include: all alarm and alarm clear conditions, all alarm acknowledgements by the operator, all changes of state of discrete points which have been designated as a logging condition, all user operations which cause a change in the data base including control actions.

Log entries associated with events detected by a field device shall be time stamped (i.e. date and time of occurrence) as detected by the DCS. Other types of log entry shall include the current date and time. Alarms and events displayed at a workstation or printed shall each include the date and time of occurrence.

Control Commands

An authorised user shall be able to control the operation of each piece of controllable equipment and override each automatic control scheme through use of control commands at the workstation. Each command shall follow a sequence which requires operator confirmation of the command before the command is executed by the system.

Calculations Capability

The system shall be provided with calculations capability which allows the user to define calculated points, either discrete or analogue, for use in control and reporting. Actual discrete and analogue points as well as calculated points shall be usable in calculations.

Data base definition

The system shall be supplied with an interactive data base definition (DBD) utility. The DBD utility shall permit only authorised users to define delete or modify elements of the system data base including but not limited to: point descriptions, field devices and communications network configuration.

Historical Data Management

An historical data management (HDM) system shall be provided for archive storage and retrieval of operational data comprising field input data, manually-entered data and calculated points.

The HDM system shall be capable of selectively increasing the rate of data capture based on events, such as process variable status, discrete inputs, or operator command. Minimum and maximum data shall include the time and date of occurrence. Gaps in collected data caused by faulty instruments or DCS system equipment shall not be included in average, minimum and maximum compilations. Archived historical data shall also include flow totals, equipment run times and number of starts compiled over daily and monthly time periods.

Report Generation

The system shall be provided with a report generator utility which shall enable authorised users to create, delete or modify report definitions. The report definitions shall allow for retrieval of data from the on-line database and from historical data files and for formatting the data for output to the printer.

The format of each report shall be definable by the user to include: the definition of static or background data, the placement of data base values, the number of significant digits of a value, the date and time of the report and calculated values.

Graphic Display Generation

The system shall be provided with an interactive on-screen graphic generation utility which shall allow an authorised user to create new graphic displays and modify or delete existing displays. The generation utility shall include an interactive linkage process allowing the user to link symbolic, numeric and bar graph representations and data entry locations to dynamic data base variables.

Text and symbols shall be able to be enlarged, shrunk, moved, mirrored or rotated with reference to a given display.

The system shall be able to represent dynamic analogue data on a graphic display as a variable length, sizeable bar graph, as well as numeric text.

Part-II DCSServer

The Server equipment speed, memory, Hard disk and operating system shall the latest at the date of Factory Acceptance Test (FAT). Server shall contain sufficient memory for all requirements described in the specification including future requirements and 100% spare capacity when all application programs are loaded and operating. The Server shall be equipped with a storage facility for data backup.

Each DCS server unit shall be provided hot standby failsafe fault-tolerant server with dual processor. The applications shall be loaded between the processors and the system shall be designed and implemented such that the failure of a single processor does not inhibit full functioning of the system. In the event of such a failure, full functioning shall resume automatically.

Specification for Fault-tolerant server hardware including complete internal components;

The servers to be Fault Tolerant Servers and fail safe software to designed to allow an application to continue operation seamlessly without disruption despite of hardware and/or software failures,

* Without any delay
* Without any lost in transaction data
* Server provides the highest availability performance.
* Redundant power System
* Zero failover time
* Failure prevention
* Fault detection and isolation
* Hot-swappable components
* Built-in switched fabric Fibre Channel
* Hot-swappable components CPU / I/O module, disks
* Latest and high advanced software / hardware configuration available at the time of FAT.

Real Time Data Base Management System (RDBMS) ODBC (Open DataBase Connectivity standard) OPC (OLE for Process Control) is an industry standard.

The server at each sites, to be provided as a separate data base for the Report, Alarm, event (separately) and alarm& event.

All the operator workstations to be 24'' LED monitor shall be rack vertical mount industrial type and to be installed in the ergonomic console with secure stand for the monitors. The enclosure shall be proper ventilation for base station and furnished with suitable industrial chair. Industrial type keyboard with special function of plant to be provided

The printers (alarm/event, Report and hard copier Printers) to be installed in a dedicated Console tables.

PartIV.NotebookComputers

Laptop notebook computer shall be provided and it shall comprise all required software, cabling and documentation and a professional standard, latest type, laptop computer for use with the DCS controller and network system configuration. The Contractor shall provide a backup containing all configuration files relevant to this Contract.

The portable programming unit shall provide the capability to carry out the following:

- Upload or download configurations and applications software;
- To change configurations;
- To interrogate local and remote communications diagnostic information;
- And to display and modify control parameters.
-

It shall be possible to prepare and modify sequence programs, edit DCS controller I/O point and alarm configurations, display and retrieve historical and current data from DCS system through these notebook computers.

These remote terminals shall be base on IBM compatible notebook computers and shall be the latest at the time of delivery. These computers shall be tested during FAT conducted at Manufacturer's work place. Access through the portable terminal to DCSs must be password protected at the highest system authorization level.

The lightweight type, notebook computer shall be rugged and suitable to withstand vibration, temperature and humidity extremes commonly associated with frequent transportation and use on industrial sites.

PartvWaterApplicationonthesystem

The software shall include a series of computer based water management applications shall be provided to assist with the operation of the network:-

- Water inventory tantalisation, a computation of total product in storage and pipelines.
- Demand versus supply analysis (short-term), a computation of water supplied into the network, against demand from the system, including assessment of rises and falls of storage reservoirs.
- Demand versus supply analysis (long-term), as above but over various time frames.
- Burst main alarm.
- Reservoir inlet/outlet arrangement set-up, a pre-set operator guided 'yes/no response' application.
- Pumping output arrangement set-up, a pre-set operator guided 'yes/no response' application.
- Pumping output automatic set-up whereby the operator enters the required flow and the computer system automatically sets-up the flow route, pumps required and the throttling required. This shall involve operator intervention to activate.
- Pipemain route arrangement set-up, a pre-set operator guided 'yes/no response' application.

Reports

The system shall be provided with a report generator utility which shall enable authorised users to create, delete or modify report definitions. The report definitions shall allow for retrieval of data from the on-line database and from historical data files and for formatting the data for output to the printer.
The format of each report shall be definable by the user to include: the definition of static or background data, the placement of data base values, the number of significant digits of a value, the date and time of the report and

calculated values.
Calculation capabilities of the report-printing facility shall include but not be limited to:

- Arithmetic operations: add, subtract, multiply and divide;
- Square root;
- Absolute value;
- Average, maximum and minimum values (from historical data) including time and date stamp;
- Boolean functions: AND, OR, NOT and exclusive OR;
- Conditional function: IF... THEN;
- Date and time manipulation;
- Tests for equivalence, less than, greater than, zero, alarm status, out of range, etc.

The system shall also be provided with a report-scheduling facility for the calculation and printing of the report. Report printing shall be schedulable either on a definable periodic basis such us shift report, daily report, weekly report and monthly report, at a specific definable time and date, or on demand via an operator command from the system console.

Configurable Shift, Daily, Weekly, Monthly and Yearly reports shall be provided for each site locally in case of the availability of DCS workstation locally and at SRCC for all the connected sites separately and as a summary report for all Southern Region sites.

The reports shall include but not be limited to the following data: Available water storage for each reservoir

Total storage

Fresh Water Total storage Brackish Water Total storage Total outflow

Total inflow

Line pressures

Pump run hour time

Pump availability

TimeStamping:-

All alarms and events detected by a field device shall be real time stamped (i.e. date and time of occurrence) at DCS controller level. The time stamping at DCS controller, Control network and operator work station to be within 1 m/s.

HMI servers shall received the alarms and events with time stamp from the DCS controller and the log entries associated with events detected by a field device shall be time stamped (i.e. date and time of occurrence) as detected by the DCS controller.

The DCS manufacturer shall design the system in such way to allow the transmission of time stamp from DCS controller to HMI host. The design should be proven and implemented in previous installation.

On-offlinetrainingWorkstation

The training workstation shall be able to access all real time data from field equipment. Process simulation functions shall be configured within the Workstation to provide a full range of Operator training functions. The training workstation shall not output any data or commands to the network. This station should not be able to change any configuration in the DCS Configuration / Database under any circumstance.

E-mail

An electronic mail (e-mail) facility shall be provided which shall enable messages to be sent from any operator workstation to any other workstation in the system. The e-mail facility shall include message queuing and a 'Message Waiting' indicator. The system shall be interfaced with the complete southern region area via the microwave link and fiber optic cable to provide an integrated WAN e-mail solution for entire system. This system shall cover the entire sites covered by the new DCS system provided under this contract.

GOVERNMENT OF KUWAIT

MINISTRY OF ELECTRICITY & WATER

TECHNICAL SERVICES SECTOR

SECTION 4D

TECHNICAL SPECIFICATIONS - ELECTRICAL

FOR

CONSTRUCTION & MAINTENANCE OF 5 Nos. R.C. GROUND RESERVOIRS FOR FRESH WATER (55 m.i.g CAPACITY EACH), AND ANNEXED WORK AT MUTLA HIGH (PHASE - II)

INDEX

SPECIFICATION FOR ELECTRICAL WORKS

This section covers all the works described to be completed in every respect for commercial operation to the requirements of the engineer. Notwithstanding that any details, accessories, etc., required for the complete installation and satisfactory operation, such works shall be included in the tender.

1. SCOPE OF WORKS

Design, supply and installation of Electrical work as per Specification and Bill of Quantities and attached drawings.

The works shall include but not limited to the following: -

1. Electrical panels (i.e. MLTB, MSB, SMSB, MCC, DBs, ATS ..etc.)
2. All required and necessary power and control cables.
3. All required electrical installation for whole the project includes conduits, wiring, switches, weatherproof enclosure, light points, power points, socket points,etc.
4. All required and necessary light fitting and external light.
5. All required and necessary civil and builders' works associated with electrical works, Fire alarm system, CCTV system, telephone works.
6. **LV Systems Contractors scope:**
   - 6.0.1 Fire Alarm system for all Buildings
   - 6.0.2 Video Surveillance System (CCTV)
   - 6.0.3 IPTV System (Satellite system)
   - 6.0.4 Telephone system as per Ministry of Communication.
   - 6.0.5 Computer network with all required network cabinets, cables, ducts, data switch cables, etc.
7. UPS as per specification.
8. Earthing system.
9. Elevators as per specification.
10. Lightning system
11. Diesel Generator system
12. Intelligent Building Management System
13. Intelligent Lighting Dimming System

14. Maintenance of the whole project for **TWO** years complete with operators around the clock with required and necessary spare parts.
15. All other required items mentioned in the BOQ, specifications and drawings, to complete the works in a satisfactory operating condition.

Attn: **No variation shall be permitted for this Project.**

2. ELECTRICAL SUPPLY:

A. 415 volts, 3 phase 50 Hz.

B. 240 volts, single phase 50 Hz.

Note: The tenderer shall submit along with the tender, catalogues, to prove that the equipment rating of volts and frequency are as specified.

3. STANDARD REGULATIONS:

3.1 All electrically operated equipment and materials shall comply as minimum unless otherwise specified.

A) With latest relevant recommendations of the International Electrical Technical Commission (IEC) if available.

B) If (a) is not available with the latest relevant British Standards specifications (BSS).

C) MEW - R

D) Notes mentioned on the tender drawings.

3.2 The electrical wiring including earthing shall fully comply with rules, regulations and standards specification of electrical installation work by MEW.

4. CONTRACTOR:

4.1 Electrical Contractor

The Electrical works shall be carried out by **One contractor** who is on the Central Tender Committee's approved list of Grade '2' or above Electrical contractor. The electrical contractor must have an Electrical engineer and electrical supervisor for ensuring proper supervision of the work. The electrical engineer be available for a minimum period of 8 (eight) hours everyday at the site and the exact time shall be arranged between the contractor and the Ministry of Electricity & Water's Electrical engineer, the electrical Supervisor should be available at site during the working hours.

The electrical contractor shall be wholly responsible for the proper execution of the electrical installation section of the complete specification and MEW will not issue a

Certificate of Acceptance until the entire Electrical works are completed in all respect.

4.2 **Supervising Electrical Engineer:**

1. The contractor shall appoint experienced supervising engineer who shall be interviewed and approved by the Ministry's representative. The electrical engineer must have Ten years' experience in Kuwait, and must have license from M.E.W as approved Supervising engineer.

2. The contractor shall state the name of Supervising Engineer giving in details of his qualifications and experience and his Kuwait Engineers Society Membership Certificate.

3. Ministry reserves the right to deduct KD.20,000/- if the electrical works are not carried out by contractor Grade '2' or above, and shall withdraw the project from the contractor.

4.3 Electrical supervisor Foreman must have diploma and 15 years' total experience and out of it 10 years shall be in Kuwait.

4.4 **LV Contractor Scope of work as mentioned at (1.6)**

Minimum requirements for Specialist LV Systems sub-contractor must be: -

a) an ISO 9001 quality management system certified company.

b) a Kuwait Fire Department Class 1 certified company of Fire Alarm

c) an approved / registered at MOC.

d) a minimum of 10 years of experience in low voltage systems.

e) must have stores/maintenance workshop locations.

f) must have an agency agreement with the manufacturer of Fire Alarm system, CCTV system.

g) must submit proof of successfully completing government contracts for last 5 years.

4.5**. LV Switchgear Vendor**

a. LV Switchgear (MLTB, MSB, SMSB, MCC) shall be sourced from a specialist Original Equipment Manufacturer.

b. Alternatively, the LV Switchgear shall be sourced from an experienced Panel builder who is Certified by the Original Manufacturer. Such Panel builders shall have atleast 10 years of experience in similar field in the State of Kuwait and shall be approved by MEW.

c. The Original manufacturer / Panel builder shall be ISO 9001, ISO 14001, ISO 18001 certified

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5. DRAWING AND TECHNICAL CATALOGUE:

5.1 General

5.1.1 Electrical contract drawings are intended to show the general arrangement of work and the appropriate location of equipment.

5.1.2 The Contractor shall refer to all other architectural and mechanical drawings to verify all spaces, dimensions and conditions affecting the electrical work and to ascertain the location and routing of all gas and with services, ducts, pipes, etc. so as to maintain adequate clearance and fully co-ordinate the electrical work with these services and shelf location in each store.

5.1.3 When departures from drawings are deemed necessary for any reason, details of such departures and reasons therefore shall be submitted to the Engineer for approval.

5.1.4 The contractor shall submit for approval of the M.E.W engineer, detailed working drawings. Working drawings shall be prepared in 1:50 scale as directed by the engineer, in A-1 size only and submitted in four (4) copies and computer disk for minimum. Works at site must not be started until and unless working drawing approval by engineer.

5.2 Working Drawings (On AutoCAD)

5.2.1 The Contractor shall prepare and submit for approval, full coordination between services, before commencing any portion of the work complete and fully detailed working drawings for Load Management system on design drawings and taking into consideration any modifications to the building or the installation which may have taken place and incorporating details of the actual equipment to be installed.

5.2.2 The working drawings shall detail the following:

a. Exact routing of cables, cables trenches, and cable ducts including sizes and details of installation.

b. Cable trays including routing, sizes and details of cables carried supports and hangers.

c. Exact runs of conduits and trunking including sizes, method of installation, draw boxes and the number of size of wires in each run.

d. Lighting layouts showing positions and types of luminaries, switch positions, wiring and details of fixing luminaries after fully co-ordinate with all other services and shelf location.

e. Earthing system with details, components, cabling and final connection arrangement.

f. Switch boards and distribution boards including location, layout, dimensions, fixing details, components, cabling and final connection arrangement.

g. Schematic distribution of main and final circuits.

h. Proposed supports and hangers for cable trays, trunking, conduits, cables, etc. including details of material, finish, sizes and method of fixing the structure.

i. Wiring diagram for a switchboard showing of the offered bus bar, circuit breaker, in addition to the protection range of all interlocks, controls, etc.

j. Dimensional drawings (scale not more than 1:50) the general layout of the equipment, cables ducts, cable trenches, cable routes, earthing system, etc.

k. Full dimensioned drawings of switchboards ("scale not less than 1:50). This drawing shall be shown the internal and external layout, cross section of bus bars, maintenance access doors, and protection provided against contact with any.

l. Live part method of ventilation.

m. Full details of all the electrical equipment supported by the catalogue.

n. The current characteristics curve for all circuit breakers protection, overloads, fuse relays etc.

o. Civil and Builders drawing associate with electrical work.

p. Full details of Computer network system.

q. Full details of lighting system for all indoor and outdoor light.

r. Full details of all equipment and control panel

s. Full details of Fans starter panels.

t. Full details of IPTV system, Access Control system, IP Telephony, Audio & Visual system, Public Address system, IP CCTV system, Fire alarm system.

u. Full details of lightning system

v. Full details of earthing system.

5.2.3 **<u>As-Built Drawings</u>**:

1. Up on completion of the installation, the Contractor shall provide as-built drawings showing all the services as they are actually installed including all revisions.

2. Three print sets of the as-built drawings shall be submitted for review by the engineer. After making any changes or modifications required by the Engineer,

one complete set of as-built drawings on AutoCAD by computer shall be submitted.

3. The contractor shall supply and install Electrical schematic Diagram for each panel on the wall in the Electrical room. The diagram shall be enclosed in a lockable cabinet with safety glass enclosure, with approximate dimension 2M x 1.2M x 0.3M. Ministry has the right to deduct KD.2000/- for each lockable cabinet with safety glass enclosure not install.

6. BUILDER'S WORKS:

The Contractor shall be responsible for all builders works associated with laying electrical cable, control cables, Fire alarm cables, Computer network cable, Load management System and BMS cables, Telephone cables, CCTV Cable and other electrical installation under this contract such as digging and excavation, constructing hand hole, cable trenches, manhole complete with manhole cover, dismantling false ceiling and reinstallation, provide new false ceiling if necessary, cable ducts for feeding cable back filling and finishing to the satisfaction of the engineer. The routing and locating of electrical service shall be in accordance with working drawing(s) duly approved by the engineer.

6.1 Should any obstruction be discovered while excavating existing premises for the purposes of intended installation work, it will be the responsibility of the contractor to re-route and re-located his installation work or the obstructing services after prior approval by the engineer.

6.2 All outdoor Power Cables should run in 150mm U.P.V.C. concrete incased ducts as a minimum and manholes should be provided each 15 meter as maximum and at cable bends.

6.3 All outdoor Telephone cables should run in U.P.V.C. ducts and manholes as Ministry of Communication's (M.O.C) Regulations.

6.4 All outdoor Low current (Data, Fire Alarm, CCTV, etc…) Cables should run in 4-Way 100mm U.P.V.C. concrete incased ducts as a minimum and manholes should be provided each 30 meter as maximum and at cable bends.

6.5 All manholes for power cable shall be from reinforced concrete (K350) complete with heavy duty cast iron cover and shall have waterproofing membrane around the walls and below the floor slab, and shall be suitable size (1m x 1m x 1m, 2m x 2m x 2m, 1.5m x 1.5m x 1.5m).

Size	Wall thickness (cm)
1m x 1m x 1m	30
2m x 2m x 2m	35
3m x 3m x 2m	40
1.5m x 1.5m x 1.5m	35

Roof slab thickness shall be minimum 30 cm.

Roof reinforcement shall be 16mm dia @ 150mm c/c at bottom and 12mm dia @200mm c/c at top.

Wall reinforcement shall be 14mm @150mm c/c both direction.

Floor reinforcement shall be 14mm @ 150mm c/c both direction.

10cm blinding concrete (N150) shall be laid below the Floor slab.

This reinforcement is for guidance only and the contractor has to submit structural design for the M.H. before construction.

6.6 The price of builders' work includes modifying the shaft and bit to suit the standard of elevator without extra time or money.

6.7 The price of builders' work includes modifying the size of electrical rooms, mechanical room to suit the size of the switchboards, without extra time or money.

6.8 The tenderer is required to visit the site of work under the contract and thoroughly investigate the existing conditions and fully account for all such works. Claims additional payment on account of such work overlooked by the tenderer at the time of pricing the tender shall not be entertained.

7. GENERAL NOTES FOR WHOLE PROJECT:

7.1 The Bill of Quantity is re-measured.

7.2 The contractor shall make complete survey of the site to prevent damage of existing services.

7.3 All manholes shall be reinforced concrete with heavy duty cast iron cover.

7.4 The minimum depth of cable duct shall be 70 cm and casing of cable duct should be by concrete.

7.5 Complete manufacturer's drawing of the panels including layout of panels inside the electrical room shall be submitted with the offer. Offer without the above shall be technically rejected.

7.6 Contractor shall be responsible to obtain approval for civil drawing of substation from MEW – Civil work Distribution Department and execute all requirements without extra money.

7.7 All Fire Alarm cables shall be Fire Retardant, low smoke cable approved from K.F.D.

7.8 All opening on concrete shall be done safely by boring.

7.9 The time of supply all materials used in electrical works (cables, panel, CCTV, Telephone, Lighting system, etc.), 6 months as maximum from the date of signing the contract. The offer shall be provided with complete schedule of installation. In case of delay, a penalty of 100/- KD shall be imposed per day.

7.10 It shall include cost for all shop drawings, working drawings, as built drawings, materials, equipment, layout, profit, overhead charges. All approvals, inspections and follow-up required by relevant concerned statutory authorities, Kuwait Municipality and Ministries for connection of Electrical, Telephone and KFD services and shall carry out any reasonable changes (as instructed by the Engineer) required to put the complete system in perfect working order to the satisfaction of the Engineer without any extra cost or extension of time.

7.11 Standard abbreviations and symbols are used in the drawings and Bills, the meaning of which are commonly understood by the profession and trade. No claims will be entertained for misunderstanding, wrong or incorrect interpretation.

7.12 The contractor is fully responsible to modify all Telephone installation according to latest MOC regulation and make any correction, modification required and he is responsible to get MOC approval, KFD and Kuwait Municipality, without any extra cost or time extension.

7.13 The layout drawings shall be read in conjunction with all relevant arch, struct., Mech. and specialist drawings and specifications.

7.14 Do not scale from the layout drawings. Work according to Architectural and electrical details.

7.15 Compliance Checklist – provide a specification paragraph-by-paragraph listing of strict word – for word compliance or non-compliance. For each item of conditional or noncompliance, spell out the vendor's substitute response to the feature excepted.

7.16 Minimum conduit size shall be 20 mm. unless otherwise indicated and all conduit shall be concealed on the wall.

7.17 All distribution boards and signal terminal cabinets shall be installed with their top end at 180 CM A.F.F. unless otherwise indicated.

7.18 Lighting switches shall be mounted at 130 cm A.F.F. unless otherwise indicated and the exact location of light fitting and sockets shall be determined by engineer at site.

7.19 All outdoor sockets, switches, outlets, boxes and fittings shall be weather-proof.

Exact location of all mechanical equipment isolating switches and outlets shall be taken from the Mechanical drawings and coordinated with the Mech. contractors.

7.20 Exact location and mounting height of various socket outlets, junction boxes and isolating switches required for equipment shall be coordinated with equipment supplier.

7.21 Ministry reserves the right to deduct KD. 20,000/- if the LV works are not carried out by LV contractor as per specification and withdraw the project from the contractor.

7.22 All required cable glands and cable lugs for complete execution of the job shall be provided by the contractor including cable glands for Transformer.

7.23 If any deviation from the specification the Ministry reserves the right to reject the panels or materials even after approval and installation. In such case the Ministry reserves the right to Blacklist the contractor and the panel manufacturer.

7.24 All electrical panel, and control panel shall be manufactured within 6 months from the date of signing the contract.

7.25 The distance between two cables shall be double the diameter.

7.26 All cable sizes shall be as per MEW regulation taking in consideration grouping factor / voltage drop, coating cable by fire retardant material, and shall be manufactured latest by (2013 or later) . Product of the proposed cable manufacturer shall be supported with the updated documentation and certificates:

7.27 All the following equipment shall be of the latest (2013 or later) product of the proposed manufacturer and shall be supported with the updated documentation and certificates:

i) CCTV,
ii) Computer networks,
iii) Video surveillance system,
iv) IPTV satellite system
v) Measuring equipment
vi) Components of all electrical panels

7.28 All excavation works shall be done manually to prevent any damage to the existing underground services like HT tables, LT cables, Water Pipe, Telephone Cables etc. Contractor shall rectify any damage caused to the existing underground services without any additional cost.

Attn.: (No drawings of existing services are at MEW)

7.29 The contractor shall manufacture the electrical panel to suit the size of the available space in electrical room.

7.30 Exact location of light fitting inside the building and outside the building shall be coordinated with all other Services and location inside the building.

7.31 All required steel and Builder works for supports light fitting, cable tray, switch panel, modify electrical rooms to suit electrical panels or UPS, modify the shaft and bit of elevator, … etc. shall be done by contractor without extra money.

7.32 All conduits and Boxes used for electrical installation, Telephone installation and computer installation shall be imbedded in wall / slabs as possible. G.I. conduits shall be used for exposed installation.

7.33 All switchboardsMLTB, MSB, SMSB and DBs with their components shall be of ONE make with suitable coordination for fault level and discrimination.

7.34 Recessed light fitting shall be suitable for the type of false ceiling. Contractor shall coordinate with the ceiling system as well as with all other services.

7.35 Contractor shall provide all required opening, cable trenches, ducts, trays electrical manholes, hand holes, …etc. even if it is not indicated on drawings. Details of such shall be submitted for engineer's approval.

7.36 All unused portions of electrical trenches shall be covered by heavy-duty checkered steel plate.

7.37 All Cables shall be coated by Fire retardant material. Ministry has the right to deduct KD.100/- per meter for each cable not coated by fire retardant material.

7.38 **Label of Equipment**

1) Substantial brass or stainless steel diagram and rating plates shall be provided on each used equipment (i.e. Power factor correction, UPS, MLTB, MSB, M.C.C, Load Management System, Motor control centre) giving the following information as a minimum.
2) Manufacturer's name and country of origin.
3) Serial number and type/model.

4) Date of manufacture.
5) Rated voltage in volts (V)
6) Rated frequency in hertz (Hz)
7) Minimum and maximum ambient temperatures in degree Celsius (ºC)
8) Degree of protection
9) Short circuit withstand strength in Amperes (A)
10) Guarantee period.

7.39 Any equipment without label shall be rejected.

7.40 For each submittal of equipment or material, the contractor shall submit compliance statement to prove that the equipment or material comply with specifications.

7.41 The contractor shall design, supply, erect and connect the following :-

1. IP CCTV system
2. Computer networks
3. IP TV system
4. IP Telephone system.
5. Fire Alarm system
6. Lighting system complete with calculation.
7. Earthing and Lightning system.
8. Inteliigent dimmer system
9. Public address system
10. Audio and visual system
11. Access control system

7.42 The size of all 415 switch board (i.e. MLTB, MSB, SMSB, MCC, DBs, … etc.) shall be manufactured with size to suit the size of electrical rooms, mechanical rooms, … etc. The contractor shall submit with the offer layout of each electrical room showing the actual size of the switchboard. Offer without this drawing will be rejected.

8. 415 VOLT SWITCHBOARD:

M.L.T.B, M.S.B and SMSB shall be withdrawable type and shall comply to IEC 439-1 Form 4 B (i.e. separation of busbars from the junction units and separation of all junctional units including their outgoing terminals from one to another) and shall have provision to connect to load management system including current transformer, transducer, .. etc.

Test Certificate from ASTA or equivalent shall be submitted for the complete type tests as per IEC 61439

Type test certificates shall be provided for each rating (6000A, 3200A, 2500A, etc upto 100A) in the name of the proposed Panel builder mentioned as 'Manufacturer' in the type test certificates

8.0.a. Short Circuit Ratings:

415v Switchboard	Short Circuit Withstand Rating, Icw	Min Breaking Capacity, Ics=100%Icu	Voltage Rating
Generator Synchronizing Panel	100kA for 1s	100kA	- Rated Voltage, Ue=415V - Rated Insulation Voltage, Ui=1000V - Rated Impulse Withstand Voltage, Uimp=12kV
MLTB	65kA for 1s	65kA	- Rated Voltage, Ue=415V - Rated Insulation Voltage, Ui=1000V - Rated Impulse Withstand Voltage, Uimp=12kV
MSB	50kA for 1s	50kA	- Rated Voltage, Ue=415V - Rated Insulation Voltage, Ui=1000V - Rated Impulse Withstand Voltage, Uimp=8kV
MCC (1200A & above)	50kA for 1s	50kA	- Rated Voltage, Ue=415V - Rated Insulation Voltage, Ui=1000V - Rated Impulse Withstand Voltage, Uimp=8kV
SMSB (Fed from LT)	25kA for 1s	36kA	- Rated Voltage, Ue=415V - Rated Insulation Voltage, Ui=1000V - Rated Impulse Withstand Voltage, Uimp=8kV
DB	17kA for 0.25s	10kA	- Rated Voltage, Ue=415V - Rated Insulation Voltage, Ui=690V - Rated Impulse Withstand Voltage, Uimp=6kV

8.0.b. MLTB, MCC and Generator Synchronizing panels shall also be tested for the following additional type tests:

- Internal Arc Fault Containment test upto 85kA for 0.4secs as per IEC 61641, Ed.2.0.
- Seismic Withstand tests upto 2G level.

8.0.c. Type Test Certificates from ASTA, **ASEFA or equivalent Certification body (with ISO 65, EN 45011 accreditation)** shall be submitted for the complete type tests for each rating as per IEC 61439.

8.0.d. Enclosure Construction : The 415V switchboards shall be manufactured using EGI sheet steel, pre-treated, epoxy powder coated to RAL 9002 paint shade and as per details below:

415v Switchboard	Form of Construction	Sheet Metal Thickness		
		Frames	Doors, Covers	Internal Partitions
Generator Synchronizing Panel	Form-4B	2.0mm	2.0mm	1.5mm

MLTB	Form-4B	2.0mm	2.0mm	1.5mm
MSB	Form-4B	2.0mm	2.0mm	1.5mm
MCC (1200A & above)	Form-4B	2.0mm	2.0mm	1.5mm
SMSB	Form-2B	1.5mm	1.5mm	1.5mm
DB	Form-2B	1.2mm	1.2mm	1.2mm

8.0.e. Switchboard / Circuit Breaker types: The type of Circuit breakers / Motor Starters and the type of compartments in which they are installed shall be as detailed below:

415v Switchboard	ACB	MCCB	Motor Starters
Generator Synchronizing Panel	Drawout	• 630A and above : Drawout type in Fixed Compartment. • 400A and below: Plug-in type in Fixed compartment	• --
MLTB	Drawout	• 630A and above : Drawout type in Fixed Compartment. • 400A and below: Fixed type in **fully withdrawable** compartment	• --
MSB	Drawout	• 630A and above : Drawout type in Fixed Compartment. • 400A and below: Plug-in type in Fixed compartment	• --
MCC (1200A & above)	Drawout	• 630A and above : Drawout type in Fixed Compartment. • 400A and below: Fixed type in **fully withdrawable** compartment	• DOL Starters : **Fully withdrawable** compartments • Star-Delta Starters : - Upto 55kW: **Fully withdrawable** compartments - Above 55kW : Fixed compartments • Soft Starters / VFDs : Fixed compartments
SMSB	-	• Fixed MCCBs	• --

8.0.f. Circuit Breaker Protection / Control Units: The type of Protection / Control units installed in each type of switchboard shall be as detailed below:

415v Switchboard	ACB Protection / Control	MCCB Protection / Control
Generator Synchronizing Panel	• Electronic: LSIG Protection • Built-in ENERGY measurement • Motorized • Ethernet communication module • Local display unit, door mounted	• Electronic: LSI Protection • Built-in ENERGY measurement • Motorized • Ethernet communication module • Local display unit, door mounted

MLTB	• Electronic: LSIG Protection • Built-in ENERGY measurement • Motorized • Ethernet communication module • Local display unit, door mounted	• Electronic: LSI Protection • Built-in ENERGY measurement • Ethernet communication module • Local display unit, door mounted
MSB	• Electronic: LSI Protection • Built-in ENERGY measurement • Ethernet communication module • Local display unit, door mounted	• Electronic: LSI Protection • Built-in ENERGY measurement • Ethernet communication module • Local display unit, door mounted
MCC (1200A & above)	• Electronic: LSI Protection • Built-in ENERGY measurement • Motorized • Ethernet communication module • Local display unit, door mounted	• Electronic: LSI Protection • Built-in ENERGY measurement • Motorized • Ethernet communication module • Local display unit, door mounted
SMSB	-	• Electronic: LSI Protection • Built-in ENERGY measurement • Ethernet communication module

8.0.h. Intelligent Switchboards:

All major devices installed in 415V Switchgear shall be of the '**Intelligent**' type that shall be capable of communicating directly with the SCADA system as detailed below using the latest communication protocol technology. Requiremens of the SCADA system are described in Section-48 :

415v Switchboard	**Communication requirement to SCADA (using Ethernet TCP/IP protocol)**		
	ACB	**MCCB**	**Motor Starters**
Generator Synchronizing Panel	• Monitoring • Control	• Monitoring • Control	• --
MLTB	• Monitoring • Control	• Monitoring	• --
MSB	• Monitoring	• Monitoring	• --
MCC (1200A & above)	• Monitoring • Control	• Monitoring • Control	• Monitoring • Control
SMSB	• --	• Monitoring	• --

8.1 Standards (for MLTB, MSB, SMSB, MCC, DB)

The switchboards and weatherproof enclosure shall comply with ~~IEC 439-1, IEC 529, IEC 947-4.~~ IEC 61439-1, IEC 61439-2, IEC 60529, IEC 60947-2, IEC 60947-4 standards.

8.2 **Qualifications**:

The manufacturer must be regularly engaged in manufacture of similar products of types, sizes and ratings required, whose products have been in satisfactory use in similar service for not less than 10 (Ten) years and shall have a well-documented quality assurance which is ISO 9001, **ISO 14001, ISO 18001** certified.

All 415V Switchboards (Generator Switchboard, MLTB, MCC, MSB, SMSB, DB) and the SCADA system shall be supplied by ONE single manufacturer in order to ensure seamless integration between them.

The proposed panel builder shall have adequate know-how and experience to build such intelligent switchboards. They should also demonstrate fully technical availability from the original manufacturer.

8.3 **Construction**:

A. The switchboard shall consist of standard cubicles assembled together on continuous base channels to form a rigid in line flush fronted free standing, continuous switchboard assembly.

Frames are constructed from 2.0mm thick folded **EGI** sheet steel~~,~~ strengthened where necessary horizontal folded channels. Frames are enclosed (cladding) by **2.0mm** thick sheet steel screwed on the frames. Hinged doors of **2.0**mm thick sheet steel strengthened where necessary. The cubicle shall be sufficiently rigid to withstand all operating forces without deformation or damage. **The same shall be proven with a Mechanical impact withstand rating of IK10 tested as per IEC 62262 standards.**

Degree of protection for the enclosures to be minimum IP54

8.3.A.1 …Fully Withdrawable Functional units (FU)

The intelligent switchboards proposed for MLTB, MCC shall incorporate fully Withdrawable compartments (WWW) for MCCBs feeders upto 400A and for Motor Starters – DOL & Star-Delta upto 55kW.

There should be clear position indicators of the drawer, which indicate the connected, test and disconnected position. The drawer should provide an effective mechanical latch to prevent incorrect operation to avoid unexpected position changing from one position to another. The drawers should have the feasibility to be locked by 3 padlocks to prevent unauthorized insertion/withdrawal or OPEN / CLOSE operation.

In case that two drawers are of the same dimensions there shall be, as an option, a mechanical mean to prevent unwanted interchangeability of these drawers. Software-only means will not be accepted.

B. Removable gland plates fitted at suitable positions on or within the enclosure for termination of external cabling. The top corners of each suite of cubicles would be fitted with detachable lifting eyes.

C. Separate compartment for control and connection to integrated SCADA system and to the Integrated Building Management system should be provided. At all stages, full coordination must be arranged between panel's manufacturer and Integrated Building Management System. All controllers and senors shall be provided by Integrated Building Management System provider and installed by the panel's manufacturer.

D. Finishing shall be epoxy powder coated to RAL 9002 paint shade.

E. The gasket for door of the panel or weatherproof enclosure shall be from formed polyurethane.

F. Mimic diagram shall be provided in front of each panel.

8.4 '**ARC Safe' Protection**:

Distribution busbar within the functional units have an automatic shutter to protect against accidental contact. Distribution busbars to have separation between the phases.

8.4.1 Double Transfer system:

Main circuits to be mechanically separated during the point of disconnection and testing.

8.4.2 Continuous LATCH:

Continous latching system on the cable compartment and functional unit doors to increase the safety against ARC faults.

8.5 **Locking System, Hinges and Gasket**

Locking system & related hardware for indoor cabinets/enclosures shall be provided:

8.5 A. **Swing Handle Systems**

Standard: IEC 62208, 90° turn,
Material: Stainless Steel

Protection class: IP 54
Warranty: 5 years,
Approved Manufacturers: SIEMENS, ABB, SCHNEIDER GENERAL ELECTRIC and EMKA

8.5B **Hinges**

Standard:	IEC 62208
Material:	Stainless Steel or Zinc Die Cast with Powder Coating.
Warranty:	**5 years**
Approved suppliers:	EMKA, SIEMENS, ABB, SCHNEIDER, GENERAL ELECTRIC

8.5C **Gaskets**

Standard:	IEC 62208
Tolerances:	According to DIN ISO 3302-1 E2
Material:	EPDM rubber {ethylene propylene dyne Monomer (M-Class) rubber}
Supplier:	DIN ISO 9001:2000 and ISO 14001:2004 ROHS Compliant,
Warranty:	5 years

8.6 **Busbar System:**

A) A segregated busbar chamber containing three phase and neutral horizontal busbar shall extend through all units.

B) The busbars shall be uniform cross section throughout their length and shall be securely supported and braced to withstand the system fault rating specified.

C) Busbars shall be of copper and shall be sized to carry continuously the current specified on the drawing and shall be covered by PVC heat shrinks.

D) All copper busbars shall be high-pressure bolted joints.

E) All copper busbars shall have a purity of not less than 99.9% and shall be coated with Tin to a thickness of minimum 5 microns.

F) All supports of copper bus bar and the distance between supports shall be exactly the same as the type tested design as per IEC 61439-1 standards.

G) The main busbars shall be run at the top of the control centre but ample access must be provided for top cable entry. Access to busbars shall be by means of bolted plates of approved equal.

H) Temperature on surface of busbars shall be 70 Deg. C as maximum at full current rating of busbars (calculation shall be submitted) test at site and factory at full load done by contractor.

I) Vertically mounted busbars shall be provided in each cubicle containing circuit breakers or fused switches and shall be supported and braced to withstand the system fault level as the main busbars.

J) A neutral busbars shall be provided having the current carrying capacity of the main busbar. The neutral busbar shall be arranged so that the neutrals of incoming and outgoing cables can be easily connected and removable link shall be provided for each incoming and outgoing circuit.

K) A copper earth busbar sized at least 50% of the phase busbars and shall be completed length of the panel.

8.7 **Switchboard Small wiring**:

A) Switchboard wiring shall be carried out in 600/100V PVC cable to BS 6346.

B) The conductors shall be standard or flexible (where applicable) and shall be not less than 2.5 mm for control and indication circuit and not less than 2.5 mm² for CT secondary circuit.

C) Wiring within switchboard shall be marked with ferrules at each end for identification. The letters and numbers used shall correspond with the switchboard-wiring diagram.

The wiring color code shall be as follows: -

1. Phase: Red, Yellow, Blue.
2. Neutral: Black.
3. Control (AC): Black.
4. Control (DC): Grey.
5. Earth: Green, Yellow.

9. **AIR CIRCUIT BREAKERS**:

9.1 Air circuit breakers shall be of the intelligent type and shall be integrated to SCADA system as described in SECTION-43.

9.2 The circuit breakers shall comply with IEC 60947-2 and shall have service breaking capacity ICS.

9.3 The air circuit breaker shall be with draw out mechanism and three positions of the moving part shall be possible:

A. Connected Position - all auxiliary and main circuits engaged.

B. Test Position - all auxiliary circuits' engaged and main circuits disconnected.

C. Isolated Position - all circuits disconnected.

9.5 The air circuit breaker shall be provided with digital control unit similar to MCCBs.

9.6 The digital control unit for air circuit breaker shall be provided with the following:

A. Over load protection.
B. Short circuit protection.
C. Earth fault protection.
D. Digital ammeter
E. Digital power factor
F. Digital active power
G. Digital Voltmeter
H. Digital energy meter
I. Maintenance indicator
J. Integrated test
K. Data transmission

Test Certificate from ASTA or equivalent shall be submitted for the short circuit breaking capacities for each air circuit breaker.

9.7 Communication

A. Breaker Status and maintenance information should be available over power monitoring network and door mounted LCD display.

1. Breaker open or closed
2. Number of open/close operation
3. Number of breaker trips
4. Breaker loading in percent of capacity based on long time pickup setting

B. Metered values available over the power monitoring network:

1. Current per phase rms. Ground and neutral
2. Current, Three phase average rms
3. Power factor three phase
4. Real Power three phase
5. Accumalated real energy
6. Energy (Wh)
7. Present and peak demand current per phase, neutral and three-phase average

C. Minimum and Maximum readings available

1. Current per phase, ground and neutral

2. Current, three phase average rms
3. Power factor, Three phase
4. Power, Three phase (kW)

D. Energy reported values available over the network to include separate total for energy flow in each direction

E. Calculate power demand using the sliding window method with a user sleected window of 5-60 minutes, in 5 minute intervals

10. MOULDED CASE CIRCUIT BREAKERS:

10.1 The Moulded Case Circuit Breakers shall be of the intelligent type and shall be integrated to SCADA system as described in SECTION-43.They shall comply with the latest IEC standard 60947-2 and amendments.

9.2 The moulded case circuit breaker shall have the service breaking capacity ICS 65 K.A in the MLTP, 50KA in MSB and 36kA in SMSB.

9.3 Each phase of the moulded case circuit breaker shall be equipped with electronic trip for over current, short circuit protection and with inbuilt metering and remote monitoring and control facility.

9.4 The MCCB shall be of circuit disconnector type and shall be designed for isolation as defined in IEC 60947-2.

9.5 The minimum rated operational voltage (Ue) shall be 415 V A/C (50/60 Hz).

9.6 The minimum rated insulation voltage (Ui) shall be 690 V A/C 50/60 Hz.).

9.7 The minimum rated impulse withstand voltage shall be 8 kV.

9.8 The utilization category of the MCCB shall be category A upto 630A and category B for MCCB above 630A, unless otherwise specified.

9.9 Moulded case circuit breaker with earth leakage protection shall comply with the following standards:

A. IEC 947-2 Appendix B

B. IEC 255-4 & 801-2 to 5 covering protection against nuisance tripping due to transient over voltage, lighting strikes, switching of devices on the network, electrostatic discharge, radio frequency interference.

C. IEC 755 Class A, Immunity to DC components up to 6 mA.

D. All MCCB TP&N shall be with integrated communication facility to send data to Load Management System and **door mounted LCD display** for electrical

paramteres like energy, Power, Maximum demand, Power quality,~~,~~ status and Alarm.

9.10 Following functions shall be included as standard into the circuit breaker control unit of MCCB.

A. Load monitoring and control of all relevant parameter including energy, maximum demand. Power quality as per IEC 61557 – 12, conact wear, load profile and thermal image.

B. Each fault protection as indicated in the drawing.

C. Remote operation of trip functions and operational parameters to L.M.S.

D. Fault trip indication – indicating the element long time, short time instantaneous (earth fault protection if supplied) that has caused the circuit breaker to trip, signaled locally by a LED.

E. Communication to Integrated Building Management System.

F~~.~~ Local LCD based touch screen colour display for monitoring and controlling MCCB's with capabilities to monitor 8 MCCB's in each display.

10.11 **Construction:**

A. The operating mechanism shall be quick make, quick break type, with the speed of operation independent of the operators, and mechanically tip free from the operating handles so as to prevent the contacts from being held close against short circuit and overload conditions. The operating mechanism shall be constructed to operate all poles in a multiple breakers simultaneously during opening, closing and tripped conditions.

B. The MCCB shall be operated by a toggle or rotary handle and shall clearly indicate the three fundamental position ON, OFF and tripped.

C. The MCCB shall be Draw-out.

D. The MCCB shall be designed for horizontal of vertical mounting without any adverse effect on electrical performance.

10.12 **Environment:**

A) MCCB's shall be suitable for operation in pollution degree 3 environmental as stated in IEC 947-1.

B) Unless otherwise specified the MCCB shall be calibrated at 50 Deg. C.

10.13 Separately mounted moulded case circuit breakers must be housed in metal clad enclosure and shall have degree of protection IP 31 as minimum for indoor and IP 54 minimum for outdoor and must be provided with earth terminals.

10.14 Test certificate from an Independent International Testing Authority for full compliance of the moulded case circuit breaker to IEC 947-2 shall be readily available.

11. PILOT LIGHTS:

11.1 All Pilot lights and indication lamps in all panels shall have the following:

A. Light Source (LED) Protected type.

B. Degree of protection IP 65

C. Service life minimum 100,000 hours

D. Integral Transferor (supply voltage 240 V) or direct supply.

E. Minimum diameter 22 mm.

12. WEATHERPROOF ENCLOSURE:

The metal weatherproof enclosure shall be IP 65 and manufactured according IEE 529 and the test certificate from International laboratory shall be provided. The metal weatherproof enclosure shall be provided with the following:

(1) Earth terminal

(2) Neutral link

(3) Both externally and internally protected with polyester epoxy resin or equal.

(4) Recessed bottom cable gland.

(5) **Locking systems, hinges and Gaskets.**

5.1 Swing handle system for Outdoor weatherproof Cabinets / Enclosures

5.1- A. Swing Handle System

Standard:	IEC 62208, 90° turn,
Material:	Stainless Steel
Protection class:	IP 65
Warranty:	5 years,

Approved Manufacturers: SIEMENS, ABB, SCHNEIDER GENERAL ELECTRIC and EMKA.

5.1-B Hinges

Standard:	IEC 62208
Material:	Stainless Steel or Zinc Die Cast with Powder Coating.
Warranty:	5 years.
Approved suppliers:	EMKA, SIEMENS, ABB, SCHNEIDER, GENERAL ELECTIC

5.1-C **Gaskets**

Standard:	IEC 62208
Tolerances:	According to DIN ISO 3302-1 E2
Material:	EPDM rubber {ethylene propylene diene Monomer (M-Class) rubber}
Supplier:	DIN ISO 9001:2000 and ISO 14001:2004 ROHS Compliant,
Warranty:	5 years.

13. AUTOMATIC TRANSFER & BYPASS-ISOLATION SWITCHES

Division 16 – Electrical Standby Power Generator Systems

PART 1 GENERAL

1.01 Scope

A. Furnish and install automatic transfer & bypass-isolation switch (ATS/BPS) system(s) with number of poles, amperage, voltage, withstand and close-on ratings as shown on the plans. Each automatic transfer shall consist of an inherently double throw power transfer switch mechanism and a microprocessor controller to provide automatic operation. All automatic transfer & bypass-isolation switches and controllers shall be the products of the same manufacturer.

1.02 Codes and Standards

The automatic transfer switches and controls shall conform to the requirements of:

A. UL 1008 - Standard for Transfer Switch Equipment

B. IEC 60947-6-1 Low-voltage Switchgear and Controlgear; Multifunction equipment; Automatic Transfer Switching Equipment

C. NFPA 70 - National Electrical Code

D. NFPA 99 - Essential Electrical Systems for Health Care Facilities

E. NFPA 110 - Emergency and Standby Power Systems

F. IEEE Standard 446 - IEEE Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications

G. NEMA Standard ICS10-1993 (formerly ICS2-447) - AC Automatic Transfer Switches

H. UL 508 Industrial Control Equipment

1.03 Acceptable Manufacturers

Automatic transfer & bypass-isolation switches shall be from one of the following Manufacturer. Alternate bids must list any deviations from this specification.

- Automatic Switch Co.
- Russel Electric.
- Caterpillar
- Kohler

PART 2 PRODUCTS

2.01 Mechanically Held Transfer Switch

A. The transfer switch shall be electrically operated and mechanically held. The electrical operator shall be a momentarily energized, single-solenoid mechanism. Main operators which include overcurrent disconnect devices, linear motors or gears shall not be acceptable. The switch shall be mechanically interlocked to ensure only two possible positions, normal or emergency.

B. All transfer switch sizes shall use only one type of main operator for ease of maintenance and commality of parts.

C. The switch shall be positively locked and unaffected by momentary outages, so that contact pressure is maintained at a constant value and contact temperature rise is minimized for maximum reliability and operating life.

D. All main contacts shall be silver composition. Switches rated 800 amperes and above shall have segmented, blow-on construction for high withstand and close-on capability and be protected by separate arcing contacts.

E. Inspection of all contacts shall be possible from the front of the switch without disassembly of operating linkages and without disconnection of power conductors. Switches rated 600 amps and higher shall have front removable and replaceable contacts. All stationary and moveable contacts shall be replaceable without removing power conductors and/or bus bars.

F. Designs utilizing components of molded-case circuit breakers, contactors, or parts thereof, which are not intended for continuous duty, repetitive switching or transfer between two active power sources are not acceptable.

G. Neutral conductors shall be provided with fully rated overlapping neutral transfer contacts. The neutrals of the normal and emergency power sources shall be connected together only during the transfer and retransfer operation and remain connected together until power source contacts close on the source to which the transfer is being made. The overlapping neutral contacts shall not overlap for a period greater than 100 milliseconds. Neutral switching contacts which do not overlap are not acceptable.

H. Where neutral conductors are to be solidly connected as shown on the plans, a neutral conductor plate with fully rated AL-CU pressure connectors shall be provided.

2.02 Bypass-Isolation Switch

A. A two-way bypass-isolation switch shall provide manual bypass of the load to either source and permit isolation of the automatic transfer switch from all source and load power conductors. All main contacts shall be manually driven.

B. Power interconnections shall be silver-plated copper bus bar or tinned bus bar. The only field installed power connections shall be at the service and load terminals of the bypass-isolation switch. All control interwiring shall be provided with disconnect plugs.

C. Separate bypass and isolation handles shall be utilized to provide clear distinction between the functions. Handles shall be permanently affixed and operable without opening the enclosure door. Designs requiring insertion of loose operating handles or opening of the enclosure door to operate are not acceptable.

D. Bypass to the load-carrying source shall be accomplished with no interruption of power to the load (make before break contacts). Designs which disconnect the load when bypassing are not acceptable. The bypass handle shall have three operating modes: "Bypass to Normal," "Automatic," and "Bypass to Emergency." The operating speed of the bypass contacts shall be the same as the associated transfer switch and shall be independent of the speed at which the manual handle is operated. In the "Automatic" mode, the bypass contacts shall be out of the power circuit so that they will not be subjected to fault currents to which the system may be subjected.

E. The isolation handle shall provide three operating modes: "Closed," "Test," and "Open." The "Test" mode shall permit testing of the entire emergency power system, including the automatic transfer switches with no interruption of power to the load. The "Open" mode shall completely isolate the automatic transfer switch from all source and load power conductors. When in the "Open" mode, it shall be possible to completely withdraw the automatic transfer switch for inspection or maintenance to conform to code requirements without removal of power conductors or the use of any tools.

F. When the isolation switch is in the "Test" or "Open" mode, the bypass switch shall function as a manual transfer switch.

G. Designs requiring operation of key interlocks for bypass isolation or ATSs which cannot be completely withdrawn when isolated are not acceptable.

H. The ATS and Bypass will be in separate compartments segregated by an insulating barrier. The ATS and Bypass Sections will have separate doors. ATSs/ Bypass using back to back design or back to front Plug-in design are not acceptable.

2.03 Microprocessor Controller

A. The controller's sensing and logic shall be provided by a single built-in microprocessor for maximum reliability, minimum maintenance, and the ability to communicate serially through an optional serial communication module.

B. A single controller shall provide twelve selectable nominal voltages for maximum application flexibility and minimal spare part requirements. Voltage sensing shall be true RMS type and shall be accurate to $\pm$ 1% of nominal voltage. Frequency sensing shall be accurate to $\pm$ 0.2%. The panel shall be capable of operating over a temperature range of -20 to +60 degrees C and storage from -55 to +85 degrees C.

C. The controller shall be connected to the transfer switch by an interconnecting wiring harness. The harness shall include a keyed disconnect plug to enable the controller to be disconnected from the transfer switch for routine maintenance. Sensing and control logic shall be provided on multi-layer printed circuit boards. Interfacing relays shall be industrial grade plug-in type with dust covers. The panel shall be enclosed with a protective cover and be mounted separately from the transfer switch unit for safety and ease of maintenance. The protective cover shall include a built-in pocket for storage of the operator's manuals.

D. All customer connections shall be wired to a common terminal block to simplify field-wiring connections.

E. The controller shall meet or exceed the requirements for Electromagnetic Compatibility (EMC) as follows:

1.	EN 55011:1991	Emission standard - Group 1, Class A
2.	EN 50082-2:1995	Generic immunity standard, from which:
	EN 61000-4-2:1995	Electrostatic discharge (ESD) immunity
	ENV 50140:1993	Radiated Electro-Magnetic field immunity
	EN 61000-4-4:1995	Electrical fast transient (EFT) immunity
	EN 61000-4-5:1995	Surge transient immunity
	EN 61000-4-6:1996	Conducted Radio-Frequency field immunity

2.04 Enclosure

A. The ATS/BPS shall be furnished in a Type 1 enclosure unless otherwise shown on the plans.

B. All standard and optional door-mounted switches and pilot lights shall be 16-mm industrial grade type or equivalent for easy viewing & replacement. Door controls shall be provided on a separate removable plate, which can be supplied loose for open type units.

PART 3 OPERATION

3.01 Controller Display and Keypad

A. A four line, 20 character LCD display and keypad shall be an integral part of the controller for viewing all available data and setting desired operational parameters. Operational parameters shall also be available for viewing and limited control through the serial communications input port. The following parameters shall only be adjustable via DIP switches on the controlller:

1. Nominal line voltage and frequency

2. Single or three phase sensing

3. Operating parameter protection

4. Transfer operating mode configuration
(Open transition, Closed transition or Delayed transition)

All instructions and controller settings shall be easily accessible, readable and accomplished without the use of codes, calculations, or instruction manuals.

3.02 Voltage, Frequency and Phase Rotation Sensing

A. Voltage and frequency on both the normal and emergency sources (as noted below) shall be continuously monitored, with the following pickup, dropout and trip setting capabilities (values shown as % of nominal unless otherwise specified):

Parameter	Sources	Dropout / Trip	Pickup / Reset
Undervoltage	N&E,3ϕ	70 to 98%	85 to 100%
Overvoltage	N&E,3ϕ	102 to 115%	2% below trip
Underfrequency	N&E	85 to 98%	90 to 100%
Overfrequency	N&E	102 to 110%	2% below trip
Voltage unbalance	N&E	5 to 20%	1%below dropout

B. Repetitive accuracy of all settings shall be within ± 0.5% over an operating temperature range of -20°C to 60°C.

C. Voltage and frequency settings shall be field adjustable in 1% increments either locally with the display and keypad or remotely via serial communications port access.

D. The controller shall be capable (when activated by the keypad or through the serial port) of sensing the phase rotation of both the normal and emergency sources. The source shall be considered unacceptable if the phase rotation is not the preferred rotation selected (ABC or CBA).

E. Source status screens shall be provided for both normal & emergency to provide digital readout of voltage on all 3 phases, frequency, and phase rotation.

F. The controller shall include a user selectable algorithm to prevent repeated transfer cycling to a source on an installation which experiences primary side, single phase failures on a Grounded Wye – Grounded Wye transformer which regenerates voltage when unloaded. The algorithm shall also inhibit retransfer to the normal (utility) source upon detection of a single phasing condition until a dedicated timer expires, the alternate source fails, or the normal source fails completely and is restored during this time delay period. The time delays associated with this feature shall be adjustable by the user through the controller keypad and LCD.

3.03 Time Delays

A. An adjustable time delay of 0 to 6 seconds shall be provided to override momentary normal source outages and delay all transfer and engine starting signals. Capability shall be provided to extend this time delay to 60 minutes by providing an external 24 VDC power supply.

B. A time delay shall be provided on transfer to emergency, adjustable from 0 to 60 minutes, for controlled timing of transfer of loads to emergency.

C. Two time delay modes (which are independently adjustable) shall be provided on re-transfer to normal. One time delay shall be for actual normal power failures and the other for the test mode function. The time delays shall be adjustable from 0 to 60 minutes. Time delay shall be automatically bypassed if the emergency source fails and the normal source is acceptable.

D. A time delay shall be provided on shut down of engine generator for cool down, adjustable from 0 to 60 minutes.

E. A time delay activated output signal shall also be provided to drive an external relay(s) for selective load disconnect control. The controller shall have the ability to activate an adjustable 0 to 5 minute time delay in any of the following modes:

1. Prior to transfer only.

2. Prior to and after transfer.

3. Normal to emergency only.

4. Emergency to normal only.

5. Normal to emergency and emergency to normal.

6. All transfer conditions or only when both sources are available.

F. The controller shall also include the following built-in time delays for optional Closed Transition and Delayed Transition operation:

1. 1 to 5 minute time delay on failure to synchronize normal and emergency sources prior to closed transition transfer.

2. 0.1 to 9.99 second time delay on an extended parallel condition of both power sources during closed transition operation.

3. 0 to 5 minute time delay for the load disconnect position for delayed transition operation.

G. All time delays shall be adjustable in 1 second increments, except the extended parallel time, which shall be adjustable in .01 second increments.

H**.** All time delays shall be adjustable by using the LCD display and keypad or with a remote device connected to the serial communications port.

3.04 Additional Features

A. A three position momentary-type test switch shall be provided for the ***test / automatic / reset*** modes. The test position will simulate a normal source failure. The reset position shall bypass the time delays on either transfer to emergency or retransfer to normal.

B. A SPDT contact, rated 5 amps at 30 VDC, shall be provided for a low-voltage engine start signal. The start signal shall prevent dry cranking of the engine by requiring the generator set to reach proper output, and run for the duration of the cool down setting, regardless of whether the normal source restores before the load is transferred.

C. Auxiliary contacts, rated 10 amps, 250 VAC shall be provided consisting of one contact, closed when the ATS is connected to the normal source and one contact closed, when the ATS is connected to the emergency source.

D. LED indicating lights (16 mm industrial grade, type 12) shall be provided; one to indicate when the ATS is connected to the normal source (green) and one to indicate when the ATS is connected to the emergency source (red).

E. LED indicating lights (16 mm industrial grade, type 12) shall be provided and energized by controller outputs. The lights shall provide true source availability of the normal and emergency sources, as determined by the voltage sensing trip and reset settings for each source.

The following features shall be built-in to the controller, but capable of being activated through keypad programming or the serial port only when required by the user:

F. Provide the ability to select "commit/no commit to transfer" to determine whether the load should be transferred to the emergency generator if the normal source restores before the generator is ready to accept the load.

G. An Inphase monitor shall be provided in the controller. The monitor shall control transfer so that motor load inrush currents do not exceed normal starting currents, and shall not require external control of power sources. The inphase monitor shall be specifically designed for and be the product of the ATS manufacturer.

H. The controller shall be capable of accepting a normally open contact that will allow the transfer switch to function in a non-automatic mode using an external control device.

I. **Engine Exerciser -** The controller shall provide an internal engine exerciser. The engine exerciser shall allow the user to program up to seven different exercise routines. For each routine, the user shall be able to:

1. Enable or disable the routine.

2. Enable or disable transfer of the load during routine.

3. Set the start time,

- Time of day
- Day of week
- Week of month (1st, 2nd, 3rd, 4th, alternate or every)

4. Set the duration of the run.

At the end of the specified duration the switch shall transfer the load back to normal and run the generator for the specified cool down period. A 10-year life battery that supplies power to the real time clock in the event of a power loss will maintain all time and date information.

The following feature shall be built - into the controller, but capable of being activated through keypad programming or the communications interface port.

Note: The transfer switch will operate in a non-automatic mode with this feature activated.

J. Terminals shall be provided for a remote contact which opens to signal the ATS to transfer to emergency and for remote contacts which open to inhibit transfer to emergency and/or retransfer to normal. Both of these inhibit signals can be activated through the keypad or serial port.

K. System Status - The controller LCD display shall include a "System Status" screen which shall be readily accessible from any point in the menu by depressing the "ESC" key a maximum of two times. This screen shall display a clear description of the active operating sequence and switch position. For example,

Normal Failed
Load on Normal
TD Normal to Emerg
2min15s

Controllers that require multiple screens to determine system status or display "coded" system status messages, which must be explained by references in the operator's manual, are not permissible.

L. Self Diagnostics - The controller shall contain a diagnostic screen for the purpose of detecting system errors. This screen shall provide information on the status input signals to the controller which may be preventing load transfer commands from being completed.

M. Communications Interface – The controller shall be capable of interfacing, through an optional serial communication module, with a network of transfer switches, locally (up to 4000 ft.) or remotely through modem serial communications. Standard software specific for transfer switch applications shall be available by the transfer switch manufacturer. This software shall allow for the monitoring, control and setup of parameters.

N. Data Logging – The controller shall have the ability to log data and to maintain the last 99 events, even in the event of total power loss. The following events shall be time and date stamped and maintained in a non-volatile memory:

1. Event Logging

1. Data and time and reason for transfer normal to emergency.
2. Data and time and reason for transfer emergency to normal.
3. Data and time and reason for engine start.
4. Data and time engine stopped.
5. Data and time emergency source available.
6. Data and time emergency source not available.

2. Statistical Data

1. Total number of transfers.
2. Total number of transfers due to source failure.
3. Total number of days controller is energized.
4. Total number of hours both normal and emergency sources are available.

O. Communications Module - A full duplex RS485 interface shall be installed in the ATS controller to enable serial communications. The serial communications shall be capable of a direct connect or multi-drop configured network. This module shall allow for the seamless integration of existing or new communication transfer devices.

PART 4 ADDITIONAL REQUIREMENTS

4.01 Withstand and Closing Ratings

A. The ATS/BPS shall be rated to close on and withstand the available RMS symmetrical short circuit current at the ATS/BPS terminals with the type of overcurrent protection shown on the plans.

B. The ATS/BPS shall be UL listed in accordance with UL 1008 and be labeled in accordance with that standard's 1½ and 3 cycle ratings. ATS/BPSs which are not tested and labeled with 1½ and 3 cycle (any breaker) ratings and have series, or specific breaker ratings only, are not acceptable.

4.02 Tests and Certification

A. The complete ATS/BPS shall be factory tested to ensure proper operation of the individual components and correct overall sequence of operation and to ensure that the operating transfer time, voltage, frequency and time delay settings are in compliance with the specification requirements.

B. Upon request, the manufacturer shall provide a notarized letter certifying compliance with all of the requirements of this specification including compliance with the above codes and standards, and withstand and closing ratings. The certification shall identify, by serial number(s), the equipment involved. No exceptions to the specifications, other than those stipulated at the time of the submittal, shall be included in the certification.

C. The ATS/BPS manufacturer shall be certified to ISO 9001 International Quality Standard and the manufacturer shall have third party certification verifying quality assurance in design/development, production, installation and servicing in accordance with ISO 9001.

4.03 Service Representation

A. The ATS/BPS manufacturer shall maintain a national service organization of company-employed personnel located throughout the contiguous United States. The service center's personnel must be factory trained and must be on call 24 hours a day, 365 days a year.

B. The manufacturer shall maintain records of each switch, by serial number, for a minimum of 20 years.

14. SPECIFICATION FOR SYNCHRONIZING PANELS FOR LV SYSTEMS

The company manufacturing the synchronizing panels should have been building synchronizing panels for more than 15 years and shall have full experience in Generator and Synchronizing controls. The manufacturer should be the qualified and certified local representative of the Power and Controls components Supplier and should be ISO 9001 certified. The company should have fully local in house qualified

and certified personnel for Designing, Assembling, Testing, Commissioning and maintaining the system. Supplier requiring expertise from outside Kuwait is not acceptable. The Synchronizing Panel manufacturer should be an approved and regular Supplier of the Generator Supplier.

The Synchronizing panel should be an integrated single source System that is the power and controls should be integrated and assembled by a single manufacturer.

The control system should be flexible to operate on any Rating or Make of Generator and expandable for adding of additional Generators in future.

The Synchronizing system should be fully automatic and be able to handle all the load connected to it with complete load sharing of KW, KVAR, PF etc. The system should operate according to the load demand, i.e. number of generators running or on standby is automatically selected and sequenced by the system. The system should be fully operational, i.e. Generators started, synchronized and connected to the load in less than 60 sec.

Each Generator should have its individual controls for the Synchronizing, Load Sharing, Load demand and Sequencing and should not depend on a Master controller. Failure of one Generator or any controls should not affect the controls of other Generators.

The synchronizing panel will have the following minimum specification:

a) 1 no. Generator section for each Generator, with the following :
    - 1 no. Air Circuit Breaker
    - 4 Pole (Current size according to the drawings)
    - Draw out type with safety shutters.
    - Electrically operated.
    - Solid-state trip unit for over current, Short circuit protection and Earth fault protection.
    - Integrated multifunction metering.
    - Set of C/Ts.
    - 1 no. Generator management module

The module should be an integrated controller with a Colour LCD Display mounted on the door and the Controller mounted inside the panel (Controller mounted on the door

are not acceptable.) to control, protect and display all the generator functions. Systems with separate modules, PLCs, Controllers for the measurement, control and protection shall not be acceptable. The single module should have the minimum following built in function:

- Alternator Under/Over Volts Warning/Shutdown
- Alternator Under/Over Freq. Warning/Shutdown
- Under/Over Speed warning/Shutdown
- Low Oil pressure Warning/Shutdown
- High Engine Temp. Warning/Shutdown
- Low Temperature Warning
- High/Low battery Volts Warning
- Over - current Warning/Electrical Trip/Shutdown
- Reverse power Electrical Trip/Shutdown
- Phase sequence Electrical Trip/Shutdown
- Electrical Fault Shutdown
- Short Circuit Fault Electrical Trip/Shutdown
- Adjustable crank cycle/attempts
- Maintenance due Alarm function
- External Remote start input (On/load/off load /on load demand)
- Built in exercise scheduler
- Magnetic Pickup and/or Alternator speed monitoring
- Event logging of shutdown Alarms.
- Full Remote control and telemetry.
- Graphic LCD display for true multilingual use
- LCD Back-lighting for low light level operation
- System lock input
- Load switching control push – button inputs
- Security via PIN Number restricted access
- SMS messaging capability with suitable GSM Modem

The module should have the following synchronizing and Load sharing capability:

- Synchronoscope with auto sync control.

- Volts and Frequency matching
- Phase angle and Phase rotation indication.
- Dead bus sensing
- Multi-set load demand operation and load management with inbuilt priority selection.
- KW and Kvar load sharing with multiple generators.
- Direct communication from the module to the governor and AVR.

The module should have the following colour display capability:

- Generator volts L1-N, L2-N, L3-N
- Generator volts L1-L2, L2-L3, L3-L1
- Generator Amps L1, L2, L3
- Generator frequency Hz
- Generator kVA L1, L2, L3, Total
- Generator kW L1, L2, L3, Total
- Generator pf L1, L2, L3, Average
- Generator kVAr L1, L2, L3, Total
- Generator KWh
- Generator KVAh
- Generator KVArh
- Generator Phase sequence
- Synchronoscope Display with check - sync
- Engine speed RPM
- Plant Battery volts
- Engine Hours run
- Number of Start Attempts
- Remaining time until maintenance due

b) Number of Outgoing sections according to the drawings, each with :

- 1 no. Air Circuit Breaker
- 3 Pole.
- Draw out type with safety shutters.
- Electrically operated.
- Solid-state trip unit for over current, short circuit and Earth fault protection.

- 1 no. Multifunction metering for the Total Load.

c) Main Bus section :

- Common bus bar section ratings as per the drawings complete with necessary bus bar supports, insulators and barriers.

d) Master control section :

- Auto/Manual selection of the control section.
- Load anticipation control, i.e. the system should be operated automatically at full capacity before a large load is added to the system. Once the large load has started the system should return to operate at automatic load demand control.
- Outgoing Breaker controls and Indication.
- Load shedding and Load management controls with necessary sequence selection and interfacing with load ACBs and Breakers.
- Control maintenance free lead acid batteries with fully Automatic Battery charger.
- Interface controls for the auto operation of the system from the ATSs.
- A Mimic line diagram with LED lights for display of the complete Power System.
- A Multifunction meter for display of all parameters of the Total Load.

e) A Master Monitoring System for Display, Monitoring, History Logging and Data acquisition of all the operating parameters of the System.

Testing and Commissioning

- The testing, calibration and commissioning should be carried out by fully qualified personal from the panel manufacturers.
- Synchronizing of each of the parameters
- Full automatic load sharing between the generators. Load sharing of KW, KVARs & Amps.
- Sequence control of the generator based on the available load on the system.
- Load anticipation control, i.e. the system should be operated automatically at

full capacity before a large load is added to the system. Once the large load has started the system should return to operate at automatic load demand control.

- Load Breaker control and Load shedding
- Shutting down of the system.

15. DIESEL GENERATORS

MUTLA CHEMICAL BUILDING

1. SCOPE OF WORK

Design Supply, install, commission, test, operate, maintain and repair with spare parts for two years and handover in good working condition of the following:

1.1 **Provide One (1) nos. 2,720 KW/ 3,400 KVA, 415 V, 1500 rpm, 0.8 P.F, 50 Hz generator sets Prime rated capacity**.

1. Fuel daily tank for 4 hours operation or as per KFSD regulation.
2. Fuel Underground Tank for 3 Days
3. Duplex fuel Transfer pump electrically operated with a capacity of 4 times the full load fuel consumption of the D/G set, complete with panel and Fuel transfer pump manually operated.
4. Two years extended warranty.
5. Load managing system.
6. Testing complete done at both, D/G manufacturer's premises and at the site.
7. Remote monitoring of engine and generator parameters on real time basis via communication network

The entire work shall be carried out in strict accordance with this specification, D/G drawings and latest regulation/requirements/specifications applicable to such works from government authorized institutions (like M.E.W./ K.F.S.D /KNPC etc).

The general conditions of the contract and any special conditions shall be applied to the D/G installation and any part thereof, in as far as they are applicable.

The contractor shall establish full co-ordination with the owner (M.E.W.) during the execution of work.

The contractor shall submit all required samples, technical details, catalogues in English language, shop drawing and any other necessary details, drawings etc. for

approval by M.E.W. engineer prior to starting of any works. All expenses incurred during the design stage and implementation of works in the factory shall be borne by the tenderer including fares, accommodation, and etc. of ministry engineers visiting the factory.

All works (Engine, Alternator) shall be done in factory located in USA/Europe only. The completed generator package shall be factory tested first before shipping to M.E.W. The manufacturer shall submit certificates or any supporting documents that all the above mentioned works were done in factory.

1.2 415V Load Management System:

The Contractor shall provide with his offer preliminarily design for Load Management System Complete with Drawing, Catalogues failing of which offer shall be technically rejected

Load Management System shall be supplied and installed by the Diesel Generator supplier and under his scope, preferred to be the same manufacturer of diesel generator, UPS and ATS.

The approved manufacturer for Load Management Control System shall be the following:

1. SCHNEIDER
2. JOHNSON CONTROL
3. GENERAL ELECTRIC
4. ABB
5. CATERPILLAR
6. EATON
7. TERBERG
8. Any Other supplier approved by the manufacturer of Diesel Generator.

1.3 All required and necessary 415 V cable.

1.4 All required and necessary control cables.

1.5 All required and necessary civil works such as concrete foundations, cable, ducts, manholes, trenches for cables.

1.6 All required and necessary control system and modification of existing control system.

1.7 All required and necessary modification to connect ATS with MLTB complete with all required cables, control and sensors to complete the work in operation condition.

1.8 Design, supply and install complete underground diesel tank with all piping, wiring and accessories as per KNPC and KFD suitable for running all generators for 3 days at full load.

1.9 Training of the MEW staff.

1.10 All other requirement to complete the works in an operating condition to the acceptance of MEW.

1.11 The contractor shall operate, repair and maintain the Diesel Generator for a period of two years after handing over.

1.12 During the test of diesel generator the contractor shall supply diesel fuel.

1.13 During operation and maintenance MEW shall supply only diesel fuel,. Other materials required for maintenance of desired generator such as oil filters, spare parts etc. shall be supplied by Contractor.

1.14 voltage dip shall not exceed 10%.

1.15 The tenderer is required to visit the site of the work under the contract thorough out investigate the existing condition and fully account for all such works. Claims for additional payment on account of such work overlooked by the Tenderer at the time of pricing the tender shall not be entertained.

1.16 All other required items mentioned in the BOQ, specifications and drawings to complete the works in a satisfactory operation condition.

B. DIESEL GENERATOR SETS

General

1.01 General Reference

1. The work mentioned in these specifications is integral with the whole of the Project Documentation and is not intended to be interpreted outside that context.

2. Co-ordinate the work with all other services affecting the Gensets work.

1.02 Description of Work

A. Furnish all labor, materials, and equipment to install, place in operation, and field test the diesel generator sets. The complete generating sets shall be assembled by the generator manufacturer. Complete generator set shall be shipped to Kuwait and ready for installation at designated site. The diesel

generator set shall be mounted on sufficient concrete foundation inside the generator room.

B. The diesel generator sets shall be rated prime including associated, control panels and other equipment, as per the Project Documentation.

C. The equipment to be furnished under this Section generally includes but not limited to the following:

1. Diesel engine driven generator sets
2) Electric cabling for power, control and communication between different panels and DG Sets
3) Air circuit breaker (sufficient capacity) with panel and bus bars for load connection point on the side of the enclosure and shall have a weather proof cover.
4) LV switchboards
5) Control panel, load transfer and load management panels as per specifications.
6) Cooling system including radiators and water piping connections
7) Ductworks for radiators
8) Exhaust systems
9) Fuel system day tanks, bulk tanks, fuel piping, fuel transfer system and appurtenances.
10) Engine mounted electric starters, battery and battery charger.
11) Spare parts and special tools
12) Services of manufacturer's representative.

D. The Diesel Generator sets shall fully comply with all relevant contractual requirements specified in Scope of Work.

E. The Diesel Generator sets shall be arranged for either automatic or manual start on mains failure, as indicated on the Project Drawings.

1.03 Quality Assurance

A. Manufacturer's Qualification:

1. The Diesel Generator set (both Engine and Alternator) shall be the product of a single manufacturer regularly engaged as a manufacturer of such equipment. The Diesel Generator set should listed in the list of approved product brand by the Ministry of Electricity and Water.

B. Installer's Qualification:

1. All the Diesel Generator installation work shall be carried out by specialized Diesel Generator contractor. Diesel Generator contractor shall be one who is an authorized Dealer representing one of the approved makes of D/G sets. Diesel Generator installation shall be supervised, checked and tested by a qualified Dealer of the manufacturer and handover the works in perfect running order to the satisfaction of the Engineer.

C. Local Agent:

The manufacturer should have a Dealer in Kuwait who is well experienced in installation and maintenance of diesel generators of the size specified herein. The agent should have been associated with the manufacturer for a minimum period of Ten years.

D. Design Criteria:

1. All materials and equipment shall comply with relevant IEC and BS specifications or equivalent as regards quality of materials, performance and proving tests.
2. The emergency power supply system and its components shall be such as may be properly maintained and serviced without the necessity of carrying expensive spare part stocks, or being subjected to interrupted service due to the lack of spare parts.
3. The generator set shall be designed to allow easy replacement of major items subject to wear.

E. Responsibility:

Compliance with this specification shall not relieve the Contractor of responsibility to supply equipment suited to meet the specified service conditions and applicable regulations.

F. Conflict:

Where conflicts exist between this specification and other drawings, standards, codes and specifications, the most stringent shall be applied.

G. Other standards:

Equipment may comply with other National Standards subject to receipt of prior written approval from the Engineer.

1.04 Service Conditions

A. The equipment shall be suitable for continuous operation at a desert location under high ambient temperatures and humidity. The atmosphere at the Facility is generally dusty and corrosive

B. The Diesel Generator sets shall be new and in all respects suitable for operation under the service conditions stated in the Project Specification

C. The indoor or outdoor location and the type of weather protection required, eg, sun-shade structure, shall be as shown on the drawings.

D. Reliability of all equipment to perform continuously in the service conditions specified is essential. Equipment typical of that being supplied shall have been in operational use elsewhere in the similar climatic conditions for a minimum of two years. Prototype or unproven equipment not having a well-established record shall not be considered.

E. The rating of the generator sets shall be their Net output ratings after suitably derating, if applicable for the specified service conditions.

1.05 Basic Engineering Information

A. The Diesel Generator set shall be suitable for supplying power under Site conditions. The voltage, kW and kVA rated output as shown on the Single Line Diagram. The rated output shall mean the net full output for prime operation duty in Kuwait at ambient temperature up to **55 degree** Celsius at relative humidity 95%.

B. The set shall also be capable of running at 110% of rated capacity for one hour in every 12 Hours, under these conditions, at the rated speed without undue heating of the engine or alternator and without mechanical or electrical troubles.

C. The design shall be suitable for automatic remote start and shall be ready for operation at all times.

D. The Diesel Generator set shall be capable of accepting the connected loads in sequence and shall maintain the voltage and frequency tolerances specified in this specification.

E. The driver governor and fuel control system shall be designed such that no external power sources are required for their operation; that is, the driver must be capable of starting, running and stopping when all power supplies other than the battery supplies, have failed.

F. Electrical components for incorporation into the equipment shall comply with the relevant IEC standards. These shall be selected to exclude readily combustible insulating and constructional material and excessive heat generation; electrical and mechanical reliability is of the utmost importance.

1.06 Operating Philosophy

A. General:

1. Outline of plant operating philosophy for the Stand-by generator sets are given below: Final operation philosophy shall be discussed and agreed upon by engineer before ordering and start of manufacturing of control panels.

B. Normal status:

1. Diesel Generator sets shall normally be on standby and available for automatic instant start-up and switching ON of the appropriate circuit breakers on receipt of a remote signal or manual control. When at rest, those parameters which affect its availability to start and operate shall be continuously monitored and if a malfunction occurs, suitably alarmed at the generator control panel situated adjacent to the generator set and communicated to the remote control room.

C. Automatic start

1. When a loss of normal power occurs and provided automatic mode is selected, the generator set shall be started automatically by means of an under-voltage signal from the electrical distribution system.
2. A test facility shall be provided to simulate the under-voltage signal.
3. Interlocking system shall be initiated to prevent paralleling of MEW power sources; prior to connection of load.

D. Manual start

1. Provided the manual mode is selected the generator set shall be capable of being started manually by means of a local initiation and also from remote control room. When running in this mode a normal power failure shall result in an automatic connection of the generator to the switchgear bus bars.

E. Test mode

1. Starting of the Diesel Generator set shall be by manual means. This mode shall be used for engine exercising and test running operations.

F. Shutdown

1. Shutdown of the Diesel Generator set shall be manual from either the local generator control panel or remote shutdown switch.
2. The Diesel Generator set shall automatically shut down on malfunction of its essential auxiliary systems.
3. Emergency and mechanical shutdown facilities shall be provided.
4. Provision shall be made for remote emergency shutdown.

G. Remote operation and monitoring

1) Communication modules and facilities to start and stop each unit through a personal computer at local panel and also from DCS including monitoring of engine and generator parameters on real time basis via communication network shall be included.

2) Provide all necessary hardware and window-based/ equivalent software to be included.

1.07 System Responsibility

A. The standby Diesel Generator sets, generator switchboards and load switchboard shall be interconnected. The supplier of the generating system shall co-ordinate, study the loading scheme, include interlocking as necessary to achieve the requirements as shown on the drawing and as required to provide a system to prevent the generating system from stalling or faltering due to momentary or temporary overloads beyond system rating, from distribution faults, motor starting loads.

B. Co-ordinate and include interlocks with the MEW source supply to prevent parallel operation of standby generator supply with MEW supply.

1.8 Submittals

A. Shop Drawings:

1. Submit 3 Sets of shop drawings for approval.
2. Shop drawings shall be complete, as to be record drawings, not general outline drawings used for sales and guide layouts.
3. Submit a complete wiring diagram for the Diesel Generator set, drawn on a single standard size sheet, showing the following:

All components of:

- engine starting control
- engine alarm
- generator control
- battery
- battery charger
- Earthing
- transfer switch control relays

4. Interior wiring, terminals and interconnecting wiring
5. Certified dimensions and weights.
6. Submit a composite wiring diagram of the entire emergency transfer system showing all wiring between the engine starting panel, engine

generator set, control panel, LV Switchboard, Automatic transfer Scheme and Load panels etc.

7. Wiring diagrams shall clearly show:
   a. main current conductors, in heavy lines
   b. control conductors, with colour and/or number coding
   c. location of relays and apparatus
   d. description of function, type and catalogue, of all components.
8. Alternator Control Panel:
   a. submit a schematic line diagram showing:
      - Interlocks
      - Protection
      - Instruments
9. Submit general arrangement drawings of the generator installation and the generator container layout.

B. Following Product Data shall be submitted to engineer.

1. Submit the detailed information together with manufacturer's catalogues for the following:
   a. Generating set manufacturer
   b. Name and Address
   c. Generating set Model No.
   d. Radiator
   e. Fuel system
   f. Starting battery
   g. Control panel
   h. Service facilities
2. Test Certificates
3. List of Spare Parts recommended by Genset manufacturer.
4. Certified Factory Test Reports
5. Instruction Manuals for Operation and Maintenance
6. Parts Catalogue with Manufacturer address.

1.9 Period of Maintenance

A. During the specified maintenance period the sub-contractor shall repair and replace directly, at his own expense, any of the plant, material or work performed or furnished under the respective works in the Project which may develop under the conditions provided for by the Project and under proper use

in the works or that portion thereof taken over by the Engineer. The guarantee period for all electric motors shall be 2 years.

B. The sub-contractor shall obtain and submit to the Engineer all guarantees or certificates or warranty available from the manufacturers, but only as supplementary to the sub-contractor's own liabilities under the Project and in no way invalidate them.

C. The Diesel Generator sub-contractor shall be responsible for the satisfactory operation of the Diesel Generator set during the Maintenance and Guarantee Period. He shall carry out necessary inspection, preventive maintenance and testing to keep the set ready all the time. The set shall function satisfactorily during power failures. The Diesel Generator sub-contractor shall carry out routine testing of the installation once in every month throughout the Maintenance and Guarantee Period. The testing shall be carried out in presence of the Engineer. The Sub-contractor shall himself provide all electrical and mechanical spare parts, grease, lubricating oils, touch-up paints, etc., required for the maintenance of the Diesel Generator set installation. The Ministry shall be responsible only for providing diesel oil as and when required. The Diesel Generator sub-contractor shall prepare logbooks, list full details of maintenance work and each logbook entry shall be countersigned by the Engineer.

PART 2 – PRODUCTS

2.01 Diesel Generator Set

A. Generator sets shall include, but not be limited to the following:

1. Driver complete with auxiliary systems as detailed in here.

2. Generator and auxiliaries including brushless exciter and automatic voltage regulator.

4. Base frame.

5. Fuel systems and tanks.

6. Platforms and ladders for access, if required.

7. Control panel and battery charger units.

8. All associated piping, supports and consumable items.

B. Generator set assembly

1. The generator set shall be of the direct-coupled type without gearbox. The coupling shall be of the flexible type.

2. The complete assembly shall be mounted on a common base frame and shall be furnished with all necessary auxiliary equipment.
3. The assembly shall be completely pre-wired and piped requiring only connection of utility services to be operational.

C. **Base frame**

1. The generator set shall be mounted on a single steel base frame.
2. The base plate shall be a fully welded design of rigid construction suitable to support the weight of the components and withstand any unbalanced forces or tangential loads that may occur due to generator set running, thermal expansion or forces due to transportation or maneuvering during installation. The whole unit shall be fitted with anti-vibration mounting pads.
3. The base plate shall be constructed in such a way that it will not interfere with maintenance and routine servicing of the generator set, and shall be fitted with lifting and pulling lugs to facilitate installation and handing. A drip pan shall also be provided.
4. Adequate bonding conductors between the equipment and the base plate shall be provided together with two diagonally located earthing bosses on the base plate.
5. Anti-vibration mounts will normally be located under the base-frame. Isolators shall be of totally enclosed design, suitable for the environment, and possess an isolation efficiency of at least 80% in respect of all engine induced vibrations.

2.02 Diesel Engine

A. **Engine Performance**

1. Engine performance shall be in accordance with the service conditions specified and provide continuously prime power rating at the Site during emergency outages with an overload power of 10% as per clause 1.06.
2. Rating of the diesel engine shall not be less than the sum of the following:
   a. Generator power requirement.
   b. Transmission losses (if any).
   c. Auxiliary power requirements for engine operation.

B. Engine Design and Construction

1. The engine shall be of the multi-cylinder, heavy-duty type, arranged in either in-line or V configuration, water cooled. Only 4 stroke engines are acceptable.
2. The engine shall be fitted with an over speed shutdown device.
4. The engine shall be fitted with the manufacturer's standard gauge and control panel, the instruments shall include a tachometer.
5. Engine speed shall not be greater than 1500 rpm.

C. Cooling System

1. The engine shall be furnished with a cooling system having sufficient capacity for cooling the engine when the diesel generator set is delivering 110% power at the service conditions specified.
2. The cooling system shall be of the closed circuit, circulating water type, which in turn shall be air-cooled by remote vertically wall mounted radiator or remote horizontal package with AC motor driven fans.
3. The cooling water system shall be fitted with an expansion tank and pressure relief valve and shall be self-venting. An opening shall be provided in the circuit for filling the system, checking coolant level and adding make-up coolant when required. All items shall be fully drainable.
4. The cooling water circuit shall be provided with thermostatic control of the engine coolant temperature. The temperature control shall be achieved by by-passing the radiator to a proportional degree by means of a thermostatic valve. Simple throttling of the coolant circulation is not permissible.
5. Engine mounted temperature indicators shall be provided to show the temperature of cooling water entering and leaving the engine cooling circuit.
6. A jacket water heater(s) shall be provided to maintain the cooling water at a suitable temperature for rapid starting and load acceptance. The heaters shall be thermostatically controlled and arranged to prevent local overheating.
7. The cooling water heaters shall be isolated when the engine reaches normal operating temperature.
8. The radiator shall be sized to dissipate the engine heat rejection to the water at 110% of the rated load. The radiator is rated at 55 deg C ambient and shall be supplied in accordance with the engine Approved Manufacturer's standard design.
9. Radiators shall be fitted with an adequately sized expansion tank and be complete with:
    a. level gauge
    b. low water level switch

c. pressure cap

d. vent

e. drain

f. earthing

g. exhaust air ducting between radiator and wall mounted exhaust louver

10. In the case of fuel cooling , the Genset shall be equipped with fuel cooling system to withstand Kuwait's harsh summer weather condition at ambient temperature up to 55 degree Celsius at relative humidity 95% and without effecting the continuous operation of the Genset or shutting down.

D. **Fuel System**

1. The engine shall be supplied with a complete fuel oil system which shall include, but not be limited to, the following:

   a. Water and sediment trap with clean out drain.

   b. fuel feed pump with pressure relief valve.

2. Fuel feed pump suction strainers of the duplex type with replaceable cartridge elements and full flow transfer valve. The nominal filtration of the filter shall be as recommended by the engine manufacturer for satisfactory continuous operation of the engine fuel system and shall be capable of protecting the fuel pump from any entrained particles (sand, dust etc. resulting from the ambient conditions), that may be present in the fuel oil. The filter elements shall be capable of easy removal.
3. An actuated fuel isolation valve arranged for remote control shall be provided in the fuel line to the engine
4. Guards or protection for all exposed fuel lines
5. The engine shall be suitable for running on diesel oil no. 2 or latest as per KNPC specifications.
6. Daily Fuel Tank:

   a. Fuel supply to each engine shall be maintained by a separate day tank. Daily fuel tank shall be sufficient capacity for continuous run of 4 hours at full load, unless otherwise specified in the Project Documentation and subject to approval from KFSD. The daily service tank shall be manufactured from mild steel to a rectangular shape and shall be complete with the following minimum equipment and facilities: -

   b. Inspection cover

   c. vent/breather pipe

d. filler pipe connection

e. overflow connection

f. drain valve and sump drain

g. level switches to control fuel transfer pump

h. level switches to operate high and low fuel level alarm circuits in the diesel alternator set control panel

i. lifting lugs.

7. **Main Fuel Storage Tank**:

a. The Contractor shall supply and install underground cylindrical diesel oil storage tank with sufficient capacity to operate the associated diesel generator set continuously on full load for 3 days, or as specified in the Project Documentation.

b. The tank shall be welded mild steel construction suitably protected from corrosion and shall be installed in the location indicated on the drawings.

c. The standard tank size in accordance with specification BS 2594, the minimum thickness of dished end, compartment plates and shell plates shall conform to the dimension given in table 1A of the specification BS 2594.

d. The storage tank shall be complete with pipes, fittings, feed lines, vents. etc. The tank shall be of the approved underground type located outside the diesel engine room. The tank shall be provided with 600 mm inspection manhole with cover, 50 mm filling pipe with cooped filling terminal, 50 mm air vent pipe with screen outlets, isolating valve, valve drain etc.

e. Electronic fuel indicator with an audio/visual alarm shall be provided for main fuel storage tank; include proper earthing for any static electrical charges to the filling system.

f. Underground filling point (as per KNPC and KFSD regulations) with cover shall be provided. It shall be equipped with gate valve and 2.5 inches kamlock adapter for Diesel fuel tanker filling. Audio/visual level alarm shall be provided near the filling point.

g. Also the storage tank and its accessories must comply with the Kuwait regulations for generator installations.

h. The tank shall be approved for use by KNPC (Kuwait National Petroleum Company) and K.F.S.D

8. **Duplex Diesel Pumping Set:**

   a. Provide packaged type duplex, self-priming, fuel pumping and straining set with a capacity of four times the total fuel consumption of engine at full load. Pump sets shall be wired and tested. Pumps shall be activated by a switch in the day tank automatically. All pumps installed inside the generator room, shall be flame-proof and fire-resistant as per NFPA Regulations

   b. Piping shall be complete to suction, discharge and return line connections. Provide gate valves and unions arranged to permit removal of either pump while the system is in operation. Install check valves and relief valves on pump outlet and gate valves prior to pressure gauges

   c. Suction strainer shall be flanged connection, duplex type, one-piece, cast-iron body, ASTM A48 Class 30, with 1.2 mm perforation brass baskets

   d. Oil pump set shall be factory assembled on a structural steel channel beam base to include pumps, motors, flexible couplings and guards. Pump set shall be suitable for diesel oil

   e. Suitable manually operated pump shall be provided.

9. **Tank Gauges:**

   a. With gauges to indicate level of fuel in the tank. Also level sensor for continuous level measurement and High/low level contacts shall be provided. The switches and gauges shall be designed for operation from a 24 Volt DC, loop powered system.

   b. Tank fittings and pressure fittings shall be made of solid bar stock to prevent leak possibilities.

10. **Diesel Oil Piping**:

   a. Provide all diesel oil piping from storage tank to day tank fill lines, water tight fill boxes, vents, vent caps, tank foot valves, and accessories

   b. Provide swing checks valves and gate valves at pump inlets. Provide approved anti-siphon valves at high points of suction lines. Provide whatever additional valves that may be required by local regulations

   c. All piping shall be provided with ground joint unions at piece of apparatus to facilitate connecting and disconnecting

   d. All piping, unless otherwise specified, shall be schedule 40 standard weight black wrought iron pipe

   e. Steel vent pipelines shall run from the fuel oil storage tanks, carried to the proper height within building construction and terminating with vent fittings.

11. **Lubricating System**

a. The lubricating oil shall be of a type readily available internationally.

b. The lubrication system shall be positive displacement type. By-pass arrangement should be provided in case of filter clogging.

c. A heat-exchanger shall be provided for cooling the lubricating oil if necessary and this shall be of long-life type i.e. the system shall not require constant cleaning or other maintenance work. A valve for taking oil sample shall be provided. The coolant for the above shall be jacket water of the engine. That is, the cooling system of the engine and the lube-oil heat-exchanger cooling system shall work in parallel or in series.

d. If the lube-oil pressure reaches low value, the engine shall be shut down automatically and also immediately should give audible alarm together with visual indication. The lube-oil system shall be provided with means to monitor pressure at important points at the engine-monitor panel.

e. A large capacity oil sump shall be provided and incorporated in the construction of the bedplate.

f. The system of lubrication shall ensure that adequate oil is pumped to all rotating parts.

g. The system shall incorporate a level dipstick, filler cap and tube and crankcase breather pipe or outlet.

h. The capacity of the lubricating oil system shall be sufficient to enable the engine to run continuously for 12 hours at any load without replenishment.

i. Suitable manual-pumping arrangement for easy draining of the whole quantity of lube-oil into a drum shall be provided.

12. **Exhaust System:**

a. Exhaust pipes shall be of Schedule 40 black steel and of adequate size to ensure that backpressure does not exceed the value specified by the manufacturer.

b. The exhaust pipe shall be connected through airtight flexible coupling to the engine.

c. Exhaust pipes shall be adequately lagged with 75mm thick (minimum) rock wool covered with aluminium sheaths of minimum thickness 1.5mm so that to take care of exhaust gas temperature in pipes exceeding 500^0C. When exhaust pipes pass through walls or roof a suitable weatherproof sleeve or thimble shall be provided to isolate exhaust pipe from the building. A silencer of heavy duty residential type shall be provided in the exhaust system and it shall also be lagged. The operation

of casting the sleeves in the concrete, if required, will be carried out by a civil contractor.

d. Exhaust pipes and silencers shall be supported from the ceiling by special
vibration isolating hangers and the pipe shall be slanted away from the engine and a condensate trap fitted at the lowest points. Approved rain caps shall be installed at the discharge end of the exhaust pipes on the roof.

e. Suitable flexible expansion joints shall be provided along the pipe run to take care of expansion requirements.

f. The completed exhaust system shall be capable of limiting the noise level at the external outlet to 85 dB (A) at seven metres from the end of the exhaust pipe.

g. Suitable guards shall be provided with the exhaust pipe to prevent small animals/reptiles from entering.

13. **Filters**: Cleanable/replaceable elements should be provided.

a. Fuel Oil System - The system shall have the following filters fitted before the fuel injection pumps:

- A primary fuel filter of ample capacity to prevent all particles of 10 microns size or smaller.
- A secondary filter to prevent all particles down to 3 microns size or smaller.

b. Lubricating Oil System - This system should have full flow filters of sufficient capacity

- Tenderers shall give full particulars of the filters used. It shall be mentioned in if filter elements are cleanable for replaceable, in which case, the working hours after which the element and the Lubricating oil is to be replaced should be stated.

c. Intake and Exhaust System - Air is inducted to the engine manifold through

- Large capacity air cleaner
- Both filters are required due to severity of dust storms and dust suspensions in the air
- The engine exhaust line shall be fitted with flexible fitting efficient silencer to give efficient silencing with minimum backpressure and terminated outside the acoustic soundproof enclosure.

14. **Ventilation**:

a. The following ventilation works are required for the diesel engine generator room.

- Louvers and sand filters shall be provided in the generator room to meet the generator manufacturer ventilation requirements.

- Necessary ventilation design and arrangement shall be considered and provided to meet the total ventilation requirement of the generators.

15. **Governing System**:

a. The governor should be of the electronic type.

b. The engine shall run steadily at any load within its rating at its rated speed, and the changes in speed due to change in load shall be suitable for isochronous and droop control, and for local/remote speed adjustment..

c. The engine shall be provided with a governor with paralleling capabilities to enable the generator to operate in parallel with other generators.

16. **Coupling and Common Bed**:

a. The engine and the alternator shall be suitably coupled directly without interposing gear arrangement.

b. The common bed shall be provided with spring type anti-vibration mountings devices for fixing to the floor.

c. The engine vibration shall be the minimum possible and shall comply with the relevant BS. The vibratory force induced as the engine passed through resonance revolutions during starting and stopping period shall not cause any damage to the whole system.

E. **Starting system:**

The diesel engine shall be equipped with starting system detailed hereunder and as per Engineer's approval.

1. Battery Starting System:

a. Electrical engine starting shall be by electric 24 V d.c. starter motor and lead acid battery system.

b. The automatic start sequence shall be arranged such that there are 6 cranking periods of 10 seconds maximum duration, interspersed with 6 rest periods. The automatic start sequence shall be locked out after six

unsuccessful cranking periods. engaging with engine flywheel and positively dis-engaging on engine starting.

c. The engine starting control equipment shall be arranged to disconnect the battery charger to prevent it from being over-loaded during starting. The starter motor shall be of adequate power of its duty.

F. **Battery charger unit**

1. A sufficient capacity battery chargers(as per recommended by generator manufacturer) and associated distribution equipment shall be housed in free standing or wall mounting sheet steel enclosures with a degree of protection not less than IP55 .

2. The set of starting batteries shall be located in ventilated sheet steel enclosures mounted on the generator set skid. Anti-vibration mountings shall be employed.

3. The battery boxes steelwork shall be insulated by means of plastic or epoxy coating to provide suitable protection against the effects of electrolyte spillage.

4. The batteries shall normally be on a continuous float charge, with the charger maintaining the batteries in a fully charged condition, at the same time supplying any continuous standby quiescent load. Each unit shall be rated for 125% of the maximum expected load. The ampere-hour rating of the batteries shall be suitable for the starting duty specified in the paragraph entitled Start System, under the minimum ambient temperature conditions.

5. The starting battery chargers shall be of the automatic solid-state type with constant voltage and current limiting characteristic. Manual boost and float charge facilities shall be provided. The charger shall be able to operate satisfactorily with the batteries disconnected. Boost charging shall only be used where the battery characteristic permits.

6. The r.m.s value of the ripple on the charger d.c. output voltage, with the battery connected, shall not exceed 5% or the value recommended by the battery manufacturer, whichever is lower. The charging voltage level shall be adjustable within ± 10% of nominal voltage.

7. Chargers shall include the following equipment :

    a. A.C. supply on/off switch

    b. Charge indication lamps

    c. D.C. voltmeter measuring charger output voltage

d. D.C. ammeter with zero at mid-scale, measuring battery current

e. D.C. ammeter measuring charger output current

f. Fuses to protect battery charger circuits

g. Battery fuse switch

h. Battery charger fault

8. A separate charger shall be provided for each of the two sets of starting batteries. Each charger shall be sized to restore a fully discharged battery to 100% capacity within 8 hours. Battery charging shall be current limited such that isolation during cranking is not necessary.

9. Engine-driven alternators shall be provided to charge the starting batteries when the engine is running, the system shall ensure that battery charging is effectively controlled by diode steering.

10. Batteries shall be of the lead acid type. Plastic cell container material shall be non-flame propagating, mechanically shock resistant and translucent, to give a visual indication of electrolyte level.

11. Inter-cell connections shall be provided and shall be insulated or otherwise provided with protective covering to prevent inadvertent short circuiting.

12. Batteries shall be protected against the effects of over-voltage, under-voltage and overcharging in accordance with the battery manufacturer's recommendations.

13. Batteries shall be furnished in a dry condition with electrolyte liquid in separate container. Electrolyte shall be added at the time the battery is put into service and given a conditioning charge.

14. The control system battery/charger unit shall be of similar design and construction to the starting battery charger units. The battery capacity shall be adequate to support the standing load for 8 hours after mains failure and to provide control power to start the generator set after this time.

2.03 **Alternator and Exciter**

A. Generator

1. The generator shall be as per Prime rated duty. The minimum generator rating expressed in kilowatts when operating at rated voltage, frequency and power factor and connected to a virtually balanced load shall be in accordance with that specified on the Single Line Diagram.

2. The generator rated voltage and frequency shall be in accordance with that specified on the Single Line Diagram. The voltage waveform characteristics shall be sinusoidal and in accordance with the requirements of IEC 34-1.

3. The rated power factor shall be taken as 0.8 lagging.

4. The generator set shall be capable of supplying its rated output at rated power factor for voltage and frequency variation in the voltage range ±10% and frequency range ±5% occurring simultaneously.

5. The generator shall be capable of withstanding without damage a three phase, a line to line, a line to earth or two lines to earth short circuit for a period of 3 seconds when operating at rated speed and with an excitation corresponding to 5% over voltage at no-load.

6. The generator shall be capable of operating continuously at rated voltage and frequency on an unbalanced load, at rated current containing 8% negative sequence component.

7. The maximum level of the total harmonic amplitude shall not exceed 5% of the fundamental, while the maximum of any given harmonic shall not exceed 3% of the fundamental.

8. The generator shall sustain a minimum short circuit current of 300% of the generator rated current for minimum of 3 seconds.

9. The generator set shall be capable of operating continuously when supplying on Site harmonic services such as variable speed drive equipment.

B. Excitation

1. The excitation shall comprise of a direct driven rotary brush less a.c. exciter, a solid-state automatic voltage regulator, voltage adjustment facility and fault contact. The excitation system shall include a permanent magnet generator pilot exciter. The a.c. exciter shall carry a full wave rotating rectifier assembly, complete with surge suppression networks.

2. The rectifier bridge shall be three phase, full wave bridge, using diodes without fuses, resistors or capacitors. Each bridge arm shall comprise two diodes in series. Each diode shall be rated for at least twice the maximum working voltage and current. All rotating components shall be proven at values of centrifugal stress under normal operating levels and fault conditions.

3. The automatic voltage regulator shall be capable of maintaining the steady state voltage with ± 1% of the controlled value over the whole load range of the generator for power factors between 0.8 and 1.0.

4. The excitation system shall be sufficient to cover any peaking load condition that the generator is able to supply. The exciter rating shall be 130% of the excitation current required at the rated output of the generator.

5. The automatic voltage regulators shall be of the automatic solid state, continuously acting type, providing facilities for local and remote voltage adjustment with motorized potentiometers. The voltage setting range shall be ± 5% of the rated value.

6. Failure of the operating regulator shall immediately cause the standby regulator to take over with negligible disturbance to the generator operation.

7. The stator, rotor and exciter windings shall have Class "H" insulation and shall be limited to Class “H” temperature rise.

2.04 Control Panel

A. **Cabinet**

1. Heavy gauge, 2.5mm thick, sheet steel construction, totally enclosed, dust and water protected and vermin proof to IP 55.
2. A hinged, lockable door shall give access to control and instruments.
3. "Live" parts shall be secured to prevent inadvertent contact with them.
4. Controls for diesel engine, alternator, exciter, meters and alarm device shall be positioned to give ample space for removing and installing components.

B. Engine-Generator Control Panel:

The engine-generator control panel shall be of the electronic modular type utilizing environmentally sealed, solid state, micro-processor based modules for engine control and AC metering. The panel shall be capable of operating under the operating temperature range of 0 degrees to +70 degrees Celsius. The electronic control system shall employ solid-state transducers for constant monitoring of oil pressure and coolant temperature through a Single Sire Serial Data Link. Unless otherwise specified in the Project Documentation, the control panel shall provide the following features:

1. Automatic start/stop engine control with programmable safety shutdowns and associated flashing LED indicators for low oil pressure, high coolant temperature, over speed, over crank and emergency stop.
2. Adjustable 1 to 60 second cycle cranking with rest periods.
3. Cool-down timer, adjustable between 0 and 30 sec.

4. LCD digital readout for:
   - engine oil pressure (N/mg)
   - lubricant oil pressure gauge (N/mg)
   - cooling temperature (0C)
   - exhaust gas temperature gauge (0C)
   - exhaust turbo-blower pressure gauge (N/mg)
   - engine RPM
   - system DC Volts
   - engine run hours
   - eight system diagnostic codes
   - generator AC Volts
   - generator AC Amps
   - Generator frequency
   - Stator winding and driver and generator bearings temperature monitoring unit.

   It shall be of the flush fronted, door mounting type and provide a selectable digital readout for each of the temperature detectors. Alarm and trip contacts shall be provided in the form of volt free changeover contacts

   The system diagnostic codes shall be designed to enhance the system protection and to allow for trouble shooting by untrained personnel.

5. These signals shall be:
   - loss of engine speed
   - invalid engine control switch
   - internal circuit fault
   - loss of coolant temperature
   - loss of data sending unit

6. These panels shall be provided with the following controls:
   - engine control switch
   - ammeter -voltmeter phase selection
   - emergency stop
   - indicator/display test switch
   - voltage adjustment

7. The minimum DCS interface signals shall be provided as follows :
   - Fuel oil high level

- Fuel oil low level
- Ready to start
- Not available to start
- Failed to start
- Running
- Load accepted
- Common fault
- Common trip

8. A proprietary annunciator system shall be utilized for visual and audible display of alarms and shutdowns.

   The generator control panel shall include, but not be limited to the following indication and alarms:

   - Fuel oil high (day tank) - alarm and indication
   - Fuel oil low (day tank) - alarm and indication
   - Ready to start indication
   - Not available to start indication and alarm
   - Stopped indication
   - Generator fail to start alarm
   - Electric priming pump failure alarm
   - Battery charger alarms
   - Driver coolant low level alarm
   - Driver coolant temperature high alarm and shutdown
   - Driver lubricating oil temperature high alarm and shutdown
   - Driver lubricating oil pressure low alarm and shutdown
   - Driver lubricating oil filter blocked alarm
   - Driver over speed alarm and shutdown
   - Mains supply available indication
   - Generator supply available indication
   - Generator supply on load indication
   - Electrical trip alarm and shutdown
   - Generator over voltage alarm and shutdown

9. Panel Wiring:

   a. All wiring of battery charger, exciter and control panel shall be P.V.C tropical grade of adequate current carrying capacity to prevent over-heating under worst climatic conditions.

10. Terminal Board:

    a. Terminal boards shall have pairs of terminals for Incoming and Outgoing wires and not more than two wires shall be connected to any one terminal.

b. Insulating barriers shall be provided between adjacent connectors. Labels for wiring designation marks shall be provided on the fixed portion of the terminal boards as well as wires. No live metal shall be exposed at the back of the terminal boards.

c. Terminal boards having pressure type terminal lusts or equivalent shall be used so that no terminal clamp is necessary. 10% spare terminals shall be provided for each terminal board assembly.

2.05 **Terminal Boxes**

A. The ends of the generator stator winding for mains connections shall be brought out to the generator terminal box.

B. Terminals and connections shall be continuously rated for 110% of the full load current of the generator.

2.06 **Temperature Monitoring**

A. A minimum of six, two per phase, embedded resistance temperature detectors in the stator winding shall be provided with the connections brought out to a separate terminal box. These shall be the platinum resistance thermometer elements, resistance 100 ohms at 0 degree Celsius, be the 3 wire type and have a minimum dielectric strength of 3 kV.

B. Generators shall be provided with local bearing temperature indicators and two thermocouples per bearing to monitor bearing temperature.

2.07 **Vibration Limits**

A. The Diesel Generator set shall have a maximum individual effective vibration velocity, measured on the bearing housing, not exceeding 2.8 mm per sec as per class IVA in accordance with ISO 2372

2.08 **Noise Limits**

A. Sound level shall not exceed 85 dB(A) at 7 meter from the end of the exhaust pipe.

2.09 **Earthing**

A. The generator terminal boxes shall be provided with M12 external earth studs.

B. The generator frame and base frame shall be provided with an M12 external studs.

C. All metallic non-current carrying parts that are not inherently bonded together shall be bonded to the frame earth.

D. Connections from the main earth bar to components shall consist of copper strips or green/yellow PVC sheathed stranded copper conductors. Termination lugs shall be of the compression type.

2.10 Shop Test

A. Complete engine-generator sets shall be shop tested in the factory prior to shipment. Four copies of the completed certified test record shall be submitted to the Engineer within 30 days after the completed test.

B. These tests shall be sufficient to assure that the units shall operate successfully and meet all operational requirements. All consumable items, test and recording equipment shall be furnished by the manufacturer for these tests.

C. Each and every automatic shutdown devices; interlock arrangement shall be tested to the full satisfaction.

D. The shop test shall consist of but not limited to four continuous hours of operation. During the test, half hourly readings shall be recorded for the following items:

1. Time
2. Ambient temperature
3. Volts per phase
4. Current in each phase
5. Total kW
6. Power factor
7. Frequency
8. Engine jacket temperature
9. Cooling water temperature (in and out)
10. Intake manifold pressure
11. Lubricating oil pressure
12. Intake manifold temperature
13. Exhaust gas temperature
14. Liters of fuel consumed per hour compared to generated kWhr

E. After completion of all testing, the following is required:

All entrapped water shall be drained, and proper protection applied to prevent entry of water or dust during shipment and transportation or storage.

F. The factory shop test should be witnessed by Three(3) MEW engineer. (2 from ESD, 1 from water dep.) All expenses incurred by the ministry engineers during the factory shop test which include fares, accommodations, allowances, etc. shall be borne by the tenderer.

2.11 **Spares**

A. Provide spare parts that are identical to and interchangeable with similar parts installed.

B. Provide recommended spare parts for 2 years of standby operation of each Genset and one tool kit.

C. The Contractor shall include in his offer, a detailed list of the manufacturer's recommended spare parts for a period of two years and all test equipment required, for trouble free maintenance of the proposed system.

PART 3 - EXECUTION

3.01 **Installation**

A. Product Delivery, Storage Handling:

1. Lift all Diesel Generator equipment-using eyes, yokes and skids provided by the manufacturer

2. Do not store equipment assemblies exposed to weather.

3. Physically protect all generator equipment against damage from work of other trades.

4. Cover all generator equipment with suitable material to avoid damage to finish.

5. Contractor shall submit the calculation to prove the adequacy of capacity of the crane he intends to use for installation of the Diesel Generator set.

B. Installation:

1. The engine and generator shall be properly aligned and mounted on a common steel base through resilient mountings to prevent vibrations Foundation and other builder's work shall be as recommended by the manufacturer and approved by the Engineer.

2. Except as may be described in this Section or shown on the drawings carry out installation strictly in accordance with the manufacturer's recommendation.

C. 415 V switchboard:

1. Install, test and commission the 415 V switchboard as indicated on the drawing and as per its specifications.
2. Install, test and commission the neutral system including resistors and system earthing.

D. Power, control, signal and data cable-works:

1. Run, connect, test and commission the cable-work from generator to switchboard, and other equipment.

E. Control Boards:

1. Run all outgoing cables from the generator to the control boards in the floor trench as indicated on the Project Drawings.

F. Record Print:

1. Fix record print of each Diesel Generator set, framed behind non-glare plexiglass, on a wall near the generator control room.

3.02 **Paint Work**

A. Paint work of each set shall be of the highest quality to withstand the worst weather conditions specified. All steel works such as tanks, pipes, frames, louvers, ladders, platform, etc. shall be given two undercoats of anti-rust paint and two enamel finishing.

3.03 **Initial Test**

A. Each unit shall be tested in the contractor's facility prior to installation in the site.

B. The following test procedure shall be followed at 0.8 p.f.:

1. The generator shall be started and operated at 25% rated load for a period not less than $^1/_2$ hour, after which the load shall be increased to 50% of rated load and operated for the second $^1/_2$ hour.
2. The load then be increased to 100% and held continuously for a period not less than three hours. Then a 110% load will be applied for a period of one hour.
3. After the above operation, the generator shall be unloaded and run under no-load condition for at least 15 minutes.
4. A full 100% load then be applied and held for a period of not less than 15 minutes and not more than 30 minutes. The generator shall be loaded and

un-loaded (On/Off operation) at 100% in this manner for a minimum of three operations, during which the speed load recovery capabilities of the unit shall be observed and report

5. All generating set protection devices shall be tested for proper operations.
6. After this initial test, the generating set shall be operated continuously for a period of 24 hours at 80% load, during which operational log sheet shall be conducted.

3.04 Field Test

A. Upon completion of the installation and as soon as condition permits, the standby power supply system including the engine driven generators, interlocks, electrical circuits, control, automatic and manual transfers and other devices shall be tested in presence of the Engineer, by the Contractor and the service representative of the manufacturer to assure the system functions as specified. All arrangements and costs incurred by such a test shall be responsibility of the sub-contractor

B. Prior to scheduling the test, the Contractor shall notify the Engineer in writing that all requirements and provisions of the Contract Documents have been met, that all equipment are adjusted and ready for operation and that instruction and operation manuals have been submitted.

C. The test shall consist of 4 hours of continuous operation of the unit at complete site load. During the test, all readings as were taken during shop test shall be recorded at 30 minutes intervals and compared.

D. As part of field test, each of the automatic shutdown devices shall be tested and respective values recorded. Any adjustment required shall be made only on recommendation of the engine manufacturer and recorded.

E. Additional tests shall be performed to demonstrate the standby system's ability to meet the automatic starting, synchronizing, load transfer and motor starting requirements as required.

3.05 Training of Operation and Maintenance Personnel

A. The Contractor shall train a number of six Engineers who will be selected by the Engineer for the operation and maintenance of all the works within the Project before these works are handed over to the Engineer (2 from ESD, 2 from water dep. And 2 from Tech. services dep.) and 24 technicians equally divided between the three MEW departments.

B. The training shall include classroom discussion on the theory of operation of the equipment, as well as maintenance and service methods for the purchased equipment. Topics covered shall include safety, hardware layout and functions, power & control wiring, diagnostic indicators, keypad/display

interface, software mapping, programming, setup, configuration, control loop tuning, operational indicators, faults, diagnostic tools, troubleshooting, and preventive maintenance. Hands-on training shall be provided on equipment of the same design as that provided. Documentation shall be provided which shall include actual manuals for the equipment and drawings and schematics of equipment supplied for this project.

C. The training has to be carried out by qualified staff of the Contractor for each specified service and shall be provided for one month period following the Certificate of Completion.

16 DIESEL GENERATORS – CONTROL BUILDING

MUTLAA (CONTROL BUILDING)

1. SCOPE OF WORK

1.1 Design Supply, install, commission, test, operate, maintain and repair with spare parts for two years and handover in good working condition of the following:

i) **Provide Two (2) nos. 1088 KW/ 1360 KVA, 415 V, 1500 rpm, 0.8 P.F, 50 Hz generator sets Prime rated capacity**.

ii) Fuel daily tank for 4 hours operation or as per KFSD regulation.

iii) Fuel Underground Tank for 3 Days

iv) Duplex fuel Transfer pump electrically operated with a capacity of 4 times the full load fuel consumption of the D/G set, complete with panel and Fuel transfer pump manually operated.

v) Two years extended warranty.

vi) Load managing system.

vii) Testing complete done at both, D/G manufacturer's premises and at the site.

viii) Remote monitoring of engine and generator parameters on real time basis via communication network.

The entire work shall be carried out in strict accordance with this specification, D/G drawings and latest regulation/requirements/specifications applicable to such works from government authorized institutions (like M.E.W/ K.F.D /KNPC etc).

The general conditions of the contract and any special conditions shall be applied to the D/G installation and any part thereof, in as far as they are applicable.

The contractor shall establish full co-ordination with the owner (M.E.W.) during the execution of work.

The contractor shall submit all required samples, technical details, catalogues in English language, shop drawing and any other necessary details, drawings etc. for approval by M.E.W. engineer prior to starting of any works. All expenses incurred during the design stage and implementation of works in the factory shall be borne by the tenderer including fares, accommodation, and etc. of ministry engineers visiting the factory.

All works (Engine, Alternator) shall be done in factory located in USA/Europe only. The completed generator package shall be factory tested first before shipping to M.E.W. The manufacturer shall submit certificates or any supporting documents that all the above mentioned works were done in factory.

1.2 **415V Load Management System**:

The Contractor shall provide with his offer preliminarily design for Load Management System Complete with Drawing, Catalogues failing of which offer shall be Technically rejected

Load Management System shall be supplied and installed by the Diesel Generator supplier and under his scope. preferred to be the same manufacturer of diesel generator, UPS and ATS.

The approved manufacturer for Load Management Control System shall be the following:

1) SCHNEIDER
2) JOHNSON CONTROL
3) GENERAL ELECTRIC
4) ABB
5) CATERPILLAR
6) EATON
7) TERBERG
8) ANY OTHER REFUTABLE SUPPLIER

1.3 All required and necessary 415 V cable.

1.4 All required and necessary control cables.

1.5 All required and necessary cables and cable trays.

1.6 All required and necessary civil works such as concrete foundations, cable, ducts, manholes, trenches for cables.

1.7 All required and necessary control system and modification of existing control system.

1.8 All required and necessary modification to connect ATS with MLTB complete with all required cables, control and sensors to complete the work in operation condition.

1.9 Design, supply and install complete underground diesel tank with all piping, wiring and accessories as per KNPC and KFSD suitable for running all generators for 3 days at full load.

1.10 Training of the MEW staff.

1.11 All other requirement to complete the works in an operating condition to the acceptance of MEW.

1.12 The contractor shall operate, repair and maintain the Diesel Generator for a period of two years after handing over.

1.13 During the test of diesel generator the contractor shall supply diesel fuel.

1.14 During operation and maintenance MEW shall supply only diesel fuel,. Other materials required for maintenance of desired generator such as oil filters, spare parts etc. shall be supplied by Contractor.

1.15 voltage dip shall not exceed 10%.

1.16 The tenderer is required to visit the site of the work under the contract thorough out investigate the existing condition and fully account for all such works. Claims for additional payment on account of such work overlooked by the Tenderer at the time of pricing the tender shall not be entertained.

1.17 All other required items mentioned in the BOQ, specifications and drawings to complete the works in a satisfactory operation condition.

B. DIESEL GENERATOR SETS

General

1.01 **General Reference**

1. The work mentioned in these specifications is integral with the whole of the Project Documentation and is not intended to be interpreted outside that context.

2. Co-ordinate the work with all other services affecting the Gensets work.

1.02 Description of Work

A. Furnish all labor, materials, and equipment to install, place in operation, and field test the diesel generator sets. The complete generating sets shall be assembled by the generator manufacturer. Complete generator set shall be shipped to Kuwait and ready for installation at designated site. The diesel generator set shall be mounted on sufficient concrete foundation inside the generator room.

B. The diesel generator sets shall be rated prime including associated, control panels and other equipment, as per the Project Documentation.

C. The equipment to be furnished under this Section generally includes but not limited to the following:

1. Diesel engine driven generator sets

2) Electric cabling for power, control and communication between different panels and DG Sets

3) Air circuit breaker (sufficient capacity) with panel and bus bars for load connection point on the side of the enclosure and shall have a weather proof cover.
4) LV switchboards

5) Control panels, synchronizing panel, load transfer and load management panels as per specifications.

6) Cooling system including radiators and water piping connections

7) Ductworks for radiators

8) Exhaust systems

9) Fuel system day tanks, bulk tanks, fuel piping, fuel transfer system and appurtenances.

10) Engine mounted electric starters, battery and battery charger.

11) Spare parts and special tools

12) Services of manufacturer's representative.

D. The Diesel Generator sets shall fully comply with all relevant contractual requirements specified in Scope of Work.

E. The Diesel Generator sets shall be arranged for either automatic or manual start on mains failure, as indicated on the Project Drawings. The sets shall be all synchronized on the generator bus and loaded as per requirement.

1.03 Quality Assurance

A. Manufacturer's Qualification:

1. The Diesel Generator set (both Engine and Alternator) shall be the product of a single manufacturer regularly engaged as a manufacturer of such equipment. The Diesel Generator set should listed in the list of approved product brand by the Ministry of Electricity and Water.

B. Installer's Qualification:

1. All the Diesel Generator installation work shall be carried out by specialized Diesel Generator contractor. Diesel Generator contractor shall be one who is an authorized Dealer representing one of the approved makes of D/G sets. Diesel Generator installation shall be supervised, checked and tested by a qualified Dealer of the manufacturer and handover the works in perfect running order to the satisfaction of the Engineer.

C. Local Agent:

The manufacturer should have a Dealer in Kuwait who is well experienced in installation and maintenance of diesel generators of the size specified herein. The agent should have been associated with the manufacturer for a minimum period of Ten years.

D. Design Criteria:

1. All materials and equipment shall comply with relevant IEC and BS specifications or equivalent as regards quality of materials, performance and proving tests.
2. The emergency power supply system and its components shall be such as may be properly maintained and serviced without the necessity of carrying expensive spare part stocks, or being subjected to interrupted service due to the lack of spare parts.
3. The generator set shall be designed to allow easy replacement of major items subject to wear.

E. **Responsibility**:

Compliance with this specification shall not relieve the Contractor of responsibility to supply equipment suited to meet the specified service conditions and applicable regulations.

F. **Conflict:**

Where conflicts exist between this specification and other drawings, standards, codes and specifications, the most stringent shall be applied.

G. **Other standards:**

Equipment may comply with other National Standards subject to receipt of prior written approval from the Engineer.

1.04 Service Conditions

A. The equipment shall be suitable for continuous operation at a desert location under high ambient temperatures and humidity. The atmosphere at the Facility is generally dusty and corrosive

B. The Diesel Generator sets shall be new and in all respects suitable for operation under the service conditions stated in the Project Specification

C. The indoor or outdoor location and the type of weather protection required, eg, sun-shade structure, shall be as shown on the drawings.

D. Reliability of all equipment to perform continuously in the service conditions specified is essential. Equipment typical of that being supplied shall have been in operational use elsewhere in the similar climatic conditions for a minimum of two years. Prototype or unproven equipment not having a well-established record shall not be considered.

E. The rating of the generator sets shall be their Net output ratings after suitably derating, if applicable for the specified service conditions.

1.05 Basic Engineering Information

A. The Diesel Generator set shall be suitable for supplying power under Site conditions. The voltage, kW and kVA rated output as shown on the Single Line Diagram. The rated output shall mean the net full output for prime operation duty in Kuwait at ambient temperature up to **55 degree** Celsius at relative humidity 95%.

B. The set shall also be capable of running at 110% of rated capacity for one hour in every 12 Hours, under these conditions, at the rated speed without undue heating of the engine or alternator and without mechanical or electrical troubles.

C. The design shall be suitable for automatic remote start and shall be ready for operation at all times.

D. The Diesel Generator set shall be capable of accepting the connected loads in sequence and shall maintain the voltage and frequency tolerances specified in this specification.

E. The driver governor and fuel control system shall be designed such that no external power sources are required for their operation; that is, the driver must be capable of starting, running and stopping when all power supplies other than the battery supplies, have failed.

F. Electrical components for incorporation into the equipment shall comply with the relevant IEC standards. These shall be selected to exclude readily combustible insulating and constructional material and excessive heat generation; electrical and mechanical reliability is of the utmost importance.

1.06 Operating Philosophy

A. General:

1. Outline of plant operating philosophy for the Stand-by generator sets are given below: Final operation philosophy shall be discussed and agreed upon by engineer before ordering and start of manufacturing of control panels.

B. Normal status:

1. Diesel Generator sets shall normally be on standby and available for automatic instant start-up and switching ON of the appropriate circuit breakers on receipt of a remote signal or manual control. When at rest, those parameters which affect its availability to start and operate shall be continuously monitored and if a malfunction occurs, suitably alarmed at the generator control panel situated adjacent to the generator set and communicated to the remote control room.

C. Automatic start

1. When a loss of normal power occurs and provided automatic mode is selected, the generator set shall be started automatically by means of an under-voltage signal from the electrical distribution system.
2. A test facility shall be provided to simulate the under-voltage signal.
3. Interlocking system shall be initiated to prevent paralleling of MEW power sources; prior to connection of load.

D. Manual start

1. Provided the manual mode is selected the generator set shall be capable of being started manually by means of a local initiation and also from remote control room. When running in this mode a normal power failure shall result in an automatic connection of the generator to the switchgear bus bars.

E. Test mode

1. Starting of the Diesel Generator set shall be by manual means. This mode shall be used for engine exercising and test running operations.

F. Shutdown

1. Shutdown of the Diesel Generator set shall be manual from either the local generator control panel or remote shutdown switch.
2. The Diesel Generator set shall automatically shut down on malfunction of its essential auxiliary systems.
3. Emergency and mechanical shutdown facilities shall be provided.
4. Provision shall be made for remote emergency shutdown.

G. Remote operation and monitoring

1) Communication modules and facilities to start and stop each unit through a personal computer at local panel and also from DCS including monitoring of engine and generator parameters on real time basis via communication network shall be included.

2) Provide all necessary hardware and window-based/ equivalent software to be included.

1.07 System Responsibility

A. The standby Diesel Generator sets, generator switchboards and load switchboard shall be interconnected. The supplier of the generating system shall co-ordinate, study the loading scheme, include interlocking as necessary to achieve the requirements as shown on the drawing and as required to provide a system to prevent the generating system from stalling or faltering due to momentary or temporary overloads beyond system rating, from distribution faults, motor starting loads.

B. Co-ordinate and include interlocks with the MEW source supply to prevent parallel operation of standby generator supply with MEW supply.

1.8 Submittals

A. Shop Drawings:

1. Submit 3 Sets of shop drawings for approval.
2. Shop drawings shall be complete, as to be record drawings, not general outline drawings used for sales and guide layouts.
3. Submit a complete wiring diagram for the Diesel Generator set, drawn on a single standard size sheet, showing the following:

All components of:

- engine starting control
- engine alarm
- generator control
- battery
- battery charger
- Earthing
- transfer switch control relays

4. Interior wiring, terminals and interconnecting wiring
5. Certified dimensions and weights.
6. Submit a composite wiring diagram of the entire emergency transfer system showing all wiring between the engine starting panel, engine generator set, control panel, LV Switchboard, Automatic transfer Scheme and Load panels etc.
7. Wiring diagrams shall clearly show:
   a. main current conductors, in heavy lines
   b. control conductors, with colour and/or number coding
   c. location of relays and apparatus
   d. description of function, type and catalogue, of all components.
8. Alternator Control Panel:
   a. submit a schematic line diagram showing:
      - Interlocks
      - Protection
      - Instruments
9. Submit general arrangement drawings of the generator installation and the generator container layout.

B. Following Product Data shall be submitted to engineer.

1. Submit the detailed information together with manufacturer's catalogues for the following:
   a. Generating set manufacturer
   b. Name and Address
   c. Generating set Model No.
   d. Radiator
   e. Fuel system

f. Starting battery

g. Control panel

h. Service facilities

2. Test Certificates
3. List of Spare Parts recommended by Genset manufacturer.
4. Certified Factory Test Reports
5. Instruction Manuals for Operation and Maintenance
6. Parts Catalogue with Manufacturer address.

1.9 Period of Maintenance

A. During the specified maintenance period the sub-contractor shall repair and replace directly, at his own expense, any of the plant, material or work performed or furnished under the respective works in the Project which may develop under the conditions provided for by the Project and under proper use in the works or that portion thereof taken over by the Engineer. The guarantee period for all electric motors shall be 2 years.

B. The sub-contractor shall obtain and submit to the Engineer all guarantees or certificates or warranty available from the manufacturers, but only as supplementary to the sub-contractor's own liabilities under the Project and in no way invalidate them.

C. The Diesel Generator sub-contractor shall be responsible for the satisfactory operation of the Diesel Generator set during the Maintenance and Guarantee Period. He shall carry out necessary inspection, preventive maintenance and testing to keep the set ready all the time. The set shall function satisfactorily during power failures. The Diesel Generator sub-contractor shall carry out routine testing of the installation once in every month throughout the Maintenance and Guarantee Period. The testing shall be carried out in presence of the Engineer. The Sub-contractor shall himself provide all electrical and mechanical spare parts, grease, lubricating oils, touch-up paints, etc., required for the maintenance of the Diesel Generator set installation. The Ministry shall be responsible only for providing diesel oil as and when required. The Diesel Generator sub-contractor shall prepare logbooks, list full details of maintenance work and each logbook entry shall be countersigned by the Engineer.

PART 2 - PRODUCTS

2.02 Diesel Generator Set

A. Generator sets shall include, but not be limited to the following:

1. Driver complete with auxiliary systems as detailed in here.

2. Generator and auxiliaries including brushless exciter and automatic voltage regulator.

4. Base frame.

5. Fuel systems and tanks.

6. Platforms and ladders for access, if required.

7. Control panel and battery charger units.

8. All associated piping, supports and consumable items.

B. Generator set assembly

1. The generator set shall be of the direct-coupled type without gearbox. The coupling shall be of the flexible type.
2. The complete assembly shall be mounted on a common base frame and shall be furnished with all necessary auxiliary equipment.
3. The assembly shall be completely pre-wired and piped requiring only connection of utility services to be operational.

C. **Base frame**

1. The generator set shall be mounted on a single steel base frame.

2. The base plate shall be a fully welded design of rigid construction suitable to support the weight of the components and withstand any unbalanced forces or tangential loads that may occur due to generator set running, thermal expansion or forces due to transportation or maneuvering during installation. The whole unit shall be fitted with anti-vibration mounting pads.

3. The base plate shall be constructed in such a way that it will not interfere with maintenance and routine servicing of the generator set, and shall be fitted with lifting and pulling lugs to facilitate installation and handing. A drip pan shall also be provided.

4. Adequate bonding conductors between the equipment and the base plate shall be provided together with two diagonally located earthing bosses on the base plate.

5. Anti-vibration mounts will normally be located under the base-frame. Isolators shall be of totally enclosed design, suitable for the environment, and possess an isolation efficiency of at least 80% in respect of all engine induced vibrations.

2.02 Diesel Engine

A. Engine Performance

1. Engine performance shall be in accordance with the service conditions specified and provide continuously prime power rating at the Site during emergency outages with an overload power of 10% as per clause 1.06.
2. Rating of the diesel engine shall not be less than the sum of the following:
   a. Generator power requirement.
   b. Transmission losses (if any).
   c. Auxiliary power requirements for engine operation.

B. Engine Design and Construction

1. The engine shall be of the multi-cylinder, heavy-duty type, arranged in either in-line or V configuration, water cooled. Only 4 stroke engines are acceptable.
2. The engine shall be fitted with an over speed shutdown device.
4. The engine shall be fitted with the manufacturer's standard gauge and control panel, the instruments shall include a tachometer.
5. Engine speed shall not be greater than 1500 rpm.

C. Cooling System

1. The engine shall be furnished with a cooling system having sufficient capacity for cooling the engine when the diesel generator set is delivering 110% power at the service conditions specified.
2. The cooling system shall be of the closed circuit, circulating water type, which in turn shall be air-cooled by engine mounted radiator.
3. The cooling water system shall be fitted with an expansion tank and pressure relief valve and shall be self-venting. An opening shall be provided in the circuit for filling the system, checking coolant level and adding make-up coolant when required. All items shall be fully drainable.
4. The cooling water circuit shall be provided with thermostatic control of the engine coolant temperature. The temperature control shall be achieved by by-

passing the radiator to a proportional degree by means of a thermostatic valve. Simple throttling of the coolant circulation is not permissible.

5. Engine mounted temperature indicators shall be provided to show the temperature of cooling water entering and leaving the engine cooling circuit.
6. A jacket water heater(s) shall be provided to maintain the cooling water at a suitable temperature for rapid starting and load acceptance. The heaters shall be thermostatically controlled and arranged to prevent local overheating.
7. The cooling water heaters shall be isolated when the engine reaches normal operating temperature.
8. The radiator shall be sized to dissipate the engine heat rejection to the water at 110% of the rated load. The radiator is rated at 55 deg C ambient and shall be supplied in accordance with the engine Approved Manufacturer's standard design.
9. Radiators shall be fitted with an adequately sized expansion tank and be complete with:
    a. level gauge
    b. low water level switch
    c. pressure cap
    d. vent
    e. drain
    f. earthing
    g. exhaust air ducting between radiator and wall mounted exhaust louver
10. In the case of fuel cooling , the Genset shall be equipped with fuel cooling system to withstand Kuwait's harsh summer weather condition at ambient temperature up to 55 degree Celsius at relative humidity 95% and without effecting the continuous operation of the Genset or shutting down.

D. **Fuel System**

1. The engine shall be supplied with a complete fuel oil system which shall include, but not be limited to, the following:

    a. Water and sediment trap with clean out drain.
    b. fuel feed pump with pressure relief valve.

2. Fuel feed pump suction strainers of the duplex type with replaceable cartridge elements and full flow transfer valve. The nominal filtration of the filter shall be as recommended by the engine manufacturer for satisfactory continuous operation of the engine fuel system and shall be capable of protecting the fuel pump from any entrained particles (sand, dust etc. resulting from the ambient

conditions), that may be present in the fuel oil. The filter elements shall be capable of easy removal.

3. An actuated fuel isolation valve arranged for remote control shall be provided in the fuel line to the engine
4. Guards or protection for all exposed fuel lines
5. The engine shall be suitable for running on diesel oil no. 2 or latest as per KNPC specifications.
6. Daily Fuel Tank:
   a. Fuel supply to each engine shall be maintained by a separate day tank. Daily fuel tank shall be sufficient capacity for continuous run of 4 hours at full load, unless otherwise specified in the Project Documentation and subject to approval from KFSD. The daily service tank shall be manufactured from mild steel to a rectangular shape and shall be complete with the following minimum equipment and facilities: -
   b. Inspection cover
   c. vent/breather pipe
   d. filler pipe connection
   e. overflow connection
   f. drain valve and sump drain
   g. level switches to control fuel transfer pump
   h. level switches to operate high and low fuel level alarm circuits in the diesel alternator set control panel
   i. lifting lugs.

7. **Main Fuel Storage Tank**:
   a. The Contractor shall supply and install underground cylindrical diesel oil storage tank with sufficient capacity to operate the associated diesel generator set continuously on full load for 3 days, or as specified in the Project Documentation.
   b. The tank shall be welded mild steel construction suitably protected from corrosion and shall be installed in the location indicated on the drawings.
   c. The standard tank size in accordance with specification BS 2594, the minimum thickness of dished end, compartment plates and shell plates shall conform to the dimension given in table 1A of the specification BS 2594.
   d. The storage tank shall be complete with pipes, fittings, feed lines, vents. etc. The tank shall be of the approved underground type located outside the diesel engine room. The tank shall be provided with 600 mm

inspection manhole with cover, 50 mm filling pipe with cooped filling terminal, 50 mm air vent pipe with screen outlets, isolating valve, valve drain etc.

e. Electronic fuel indicator with an audio/visual alarm shall be provided for main fuel storage tank; include proper earthing for any static electrical charges to the filling system.

f. Underground filling point(as per KNPC and KFSD regulations) with cover shall be provided. It shall be equipped with gate valve and 2.5 inches kamlock adapter for Diesel fuel tanker filling. Audio/visual level alarm shall be provided near the filling point.

g. Also the storage tank and its accessories must comply with the Kuwait regulations for generator installations.

h. The tank shall be approved for use by KNPC (Kuwait National Petroleum Company) and K.F.S.D

8. **Duplex Diesel Pumping Set:**

a. Provide packaged type duplex, self-priming, fuel pumping and straining set with a capacity of four times the total fuel consumption of engine at full load. Pump sets shall be wired and tested. Pumps shall be activated by a switch in the day tank automatically. All pumps installed inside the generator room, shall be flame-proof and fire-resistant as per NFPA Regulations

b. Piping shall be complete to suction, discharge and return line connections. Provide gate valves and unions arranged to permit removal of either pump while the system is in operation. Install check valves and relief valves on pump outlet and gate valves prior to pressure gauges

c. Suction strainer shall be flanged connection, duplex type, one-piece, cast-iron body, ASTM A48 Class 30, with 1.2 mm perforation brass baskets

d. Oil pump set shall be factory assembled on a structural steel channel beam base to include pumps, motors, flexible couplings and guards. Pump set shall be suitable for diesel oil

e. Suitable manually operated pump shall be provided.

9. **Tank Gauges:**

a. With gauges to indicate level of fuel in the tank. Also level sensor for continuous level measurement and High/low level contacts shall be provided. The switches and gauges shall be designed for operation from a 24 Volt DC, loop powered system.

b. Tank fittings and pressure fittings shall be made of solid bar stock to prevent leak possibilities.

10. **Diesel Oil Piping**:

    a. Provide all diesel oil piping from storage tank to day tank fill lines, water tight fill boxes, vents, vent caps, tank foot valves, and accessories

    b. Provide swing checks valves and gate valves at pump inlets. Provide approved anti-siphon valves at high points of suction lines. Provide whatever additional valves that may be required by local regulations

    c. All piping shall be provided with ground joint unions at piece of apparatus to facilitate connecting and disconnecting

    d. All piping, unless otherwise specified, shall be schedule 40 standard weight black wrought iron pipe

    e. Steel vent pipelines shall run from the fuel oil storage tanks, carried to the proper height within building construction and terminating with vent fittings.

11. **Lubricating System**

    a. The lubricating oil shall be of a type readily available internationally.

    b. The lubrication system shall be positive displacement type. By-pass arrangement should be provided in case of filter clogging.

    c. A heat-exchanger shall be provided for cooling the lubricating oil if necessary and this shall be of long-life type i.e. the system shall not require constant cleaning or other maintenance work. A valve for taking oil sample shall be provided. The coolant for the above shall be jacket water of the engine. That is, the cooling system of the engine and the lube-oil heat-exchanger cooling system shall work in parallel or in series.

    d. If the lube-oil pressure reaches low value, the engine shall be shut down automatically and also immediately should give audible alarm together with visual indication. The lube-oil system shall be provided with means to monitor pressure at important points at the engine-monitor panel.

    e. A large capacity oil sump shall be provided and incorporated in the construction of the bedplate.

    f. The system of lubrication shall ensure that adequate oil is pumped to all rotating parts.

    g. The system shall incorporate a level dipstick, filler cap and tube and crankcase breather pipe or outlet.

    h. The capacity of the lubricating oil system shall be sufficient to enable the engine to run continuously for 12 hours at any load without replenishment.

i. Suitable manual-pumping arrangement for easy draining of the whole quantity of lube-oil into a drum shall be provided.

12. **Exhaust System:**

a. Exhaust pipes shall be of Schedule 40 black steel and of adequate size to ensure that backpressure does not exceed the value specified by the manufacturer.

b. The exhaust pipe shall be connected through airtight flexible coupling to the engine.

c. Exhaust pipes shall be adequately lagged with 75mm thick (minimum) rock wool covered with aluminium sheaths of minimum thickness 1.5mm so that to take care of exhaust gas temperature in pipes exceeding 500^0C. When exhaust pipes pass through walls or roof a suitable weatherproof sleeve or thimble shall be provided to isolate exhaust pipe from the building. A silencer of heavy duty residential type shall be provided in the exhaust system and it shall also be lagged. The operation of casting the sleeves in the concrete, if required, will be carried out by a civil contractor.

d. Exhaust pipes and silencers shall be supported from the ceiling by special
vibration isolating hangers and the pipe shall be slanted away from the engine and a condensate trap fitted at the lowest points. Approved rain caps shall be installed at the discharge end of the exhaust pipes on the roof.

e. Suitable flexible expansion joints shall be provided along the pipe run to take care of expansion requirements.

f. The completed exhaust system shall be capable of limiting the noise level at the external outlet to 85 dB (A) at seven metres from the end of the exhaust pipe.

g. Suitable guards shall be provided with the exhaust pipe to prevent small
animals/reptiles from entering.

13. **Filters**: Cleanable/replaceable elements should be provided.

a. Fuel Oil System - The system shall have the following filters fitted before the fuel injection pumps:

- A primary fuel filter of ample capacity to prevent all particles of 10 microns size or smaller.
- A secondary filter to prevent all particles down to 3 microns size or smaller.

b. Lubricating Oil System - This system should have full flow filters of sufficient capacity

- Tenderers shall give full particulars of the filters used. It shall be mentioned in if filter elements are cleanable for replaceable, in which case, the working hours after which the element and the Lubricating oil is to be replaced should be stated.

c. Intake and Exhaust System - Air is inducted to the engine manifold through

- Large capacity air cleaner
- Both filters are required due to severity of dust storms and dust suspensions in the air
- The engine exhaust line shall be fitted with flexible fitting efficient silencer to give efficient silencing with minimum backpressure and terminated outside the acoustic soundproof enclosure.

14. **Ventilation**:

a. The following ventilation works are required for the diesel engine generator
room.

- Louvers and sand filters shall be provided in the generator room to meet the generator manufacturer ventilation requirements.

- Necessary ventilation design and arrangement shall be considered and provided to meet the total ventilation requirement of the generators.

15. **Governing System**:

a. The governor should be of the electronic type.

b. The engine shall run steadily at any load within its rating at its rated speed, and the changes in speed due to change in load shall be suitable for isochronous and droop control, and for local/remote speed adjustment..

c. The engine shall be provided with a governor with paralleling capabilities to enable the generator to operate in parallel with other generators.

16. **Coupling and Common Bed**:

a. The engine and the alternator shall be suitably coupled directly without interposing gear arrangement.

b. The common bed shall be provided with spring type anti-vibration mountings devices for fixing to the floor.

c. The engine vibration shall be the minimum possible and shall comply with the relevant BS. The vibratory force induced as the engine passed through resonance revolutions during starting and stopping period shall not cause any damage to the whole system.

E. **Starting system:**

The diesel engine shall be equipped with starting system detailed hereunder and as per Engineer's approval.

1. Battery Starting System:

   a. Electrical engine starting shall be by electric 24 V d.c. starter motor and lead acid battery system.

   b. The automatic start sequence shall be arranged such that there are 6 cranking periods of 10 seconds maximum duration, interspersed with 6 rest periods. The automatic start sequence shall be locked out after six unsuccessful cranking periods. engaging with engine flywheel and positively dis-engaging on engine starting.

   c. The engine starting control equipment shall be arranged to disconnect the battery charger to prevent it from being over-loaded during starting. The starter motor shall be of adequate power of its duty.

F. **Battery charger unit**

1. A sufficient capacity battery chargers(as per recommended by generator manufacturer) and associated distribution equipment shall be housed in free standing or wall mounting sheet steel enclosures with a degree of protection not less than IP55 .

2. The set of starting batteries shall be located in ventilated sheet steel enclosures mounted on the generator set skid. Anti-vibration mountings shall be employed.

3. The battery boxes steelwork shall be insulated by means of plastic or epoxy coating to provide suitable protection against the effects of electrolyte spillage.

4. The batteries shall normally be on a continuous float charge, with the charger maintaining the batteries in a fully charged condition, at the same time supplying any continuous standby quiescent load. Each unit shall be rated for 125% of the maximum expected load. The ampere-hour rating of the batteries shall be suitable for the starting duty specified in the

paragraph entitled Start System, under the minimum ambient temperature conditions.

5. The starting battery chargers shall be of the automatic solid-state type with constant voltage and current limiting characteristic. Manual boost and float charge facilities shall be provided. The charger shall be able to operate satisfactorily with the batteries disconnected. Boost charging shall only be used where the battery characteristic permits.

6. The r.m.s value of the ripple on the charger d.c. output voltage, with the battery connected, shall not exceed 5% or the value recommended by the battery manufacturer, whichever is lower. The charging voltage level shall be adjustable within ± 10% of nominal voltage.

7. Chargers shall include the following equipment :

    a. A.C. supply on/off switch
    b. Charge indication lamps
    c. D.C. voltmeter measuring charger output voltage
    d. D.C. ammeter with zero at mid-scale, measuring battery current
    e. D.C. ammeter measuring charger output current
    f. Fuses to protect battery charger circuits
    g. Battery fuse switch
    h. Battery charger fault

8. A separate charger shall be provided for each of the two sets of starting batteries. Each charger shall be sized to restore a fully discharged battery to 100% capacity within 8 hours. Battery charging shall be current limited such that isolation during cranking is not necessary.

9. Engine-driven alternators shall be provided to charge the starting batteries when the engine is running, the system shall ensure that battery charging is effectively controlled by diode steering.

10. Batteries shall be of the lead acid type. Plastic cell container material shall be non-flame propagating, mechanically shock resistant and translucent, to give a visual indication of electrolyte level.

11. Inter-cell connections shall be provided and shall be insulated or otherwise provided with protective covering to prevent inadvertent short circuiting.

12. Batteries shall be protected against the effects of over-voltage, under-voltage and overcharging in accordance with the battery manufacturer's recommendations.

13. Batteries shall be furnished in a dry condition with electrolyte liquid in separate container. Electrolyte shall be added at the time the battery is put into service and given a conditioning charge.

14. The control system battery/charger unit shall be of similar design and construction to the starting battery charger units. The battery capacity shall be adequate to support the standing load for 8 hours after mains failure and to provide control power to start the generator set after this time.

2.04 Alternator and Exciter

A. Generator

1. The generator shall be as per Prime rated duty. The minimum generator rating expressed in kilowatts when operating at rated voltage, frequency and power factor and connected to a virtually balanced load shall be in accordance with that specified on the Single Line Diagram.

2. The generator rated voltage and frequency shall be in accordance with that specified on the Single Line Diagram. The voltage waveform characteristics shall be sinusoidal and in accordance with the requirements of IEC 34-1.

3. The rated power factor shall be taken as 0.8 lagging.

4. The generator set shall be capable of supplying its rated output at rated power factor for voltage and frequency variation in the voltage range ±10% and frequency range ±5% occurring simultaneously.

5. The generator shall be capable of withstanding without damage a three phase, a line to line, a line to earth or two lines to earth short circuit for a period of 3 seconds when operating at rated speed and with an excitation corresponding to 5% over voltage at no-load.

6. The generator shall be capable of operating continuously at rated voltage and frequency on an unbalanced load, at rated current containing 8% negative sequence component.

7. The maximum level of the total harmonic amplitude shall not exceed 5% of the fundamental, while the maximum of any given harmonic shall not exceed 3% of the fundamental.

8. The generator shall sustain a minimum short circuit current of 300% of the generator rated current for minimum of 3 seconds.

9. The generator set shall be capable of operating continuously when supplying on Site harmonic services such as variable speed drive equipment.

B. **Excitation**

1. The excitation shall comprise of a direct driven rotary brush less a.c. exciter, a solid-state automatic voltage regulator, voltage adjustment facility and fault contact. The excitation system shall include a permanent magnet generator pilot exciter. The a.c. exciter shall carry a full wave rotating rectifier assembly, complete with surge suppression networks.

2. The rectifier bridge shall be three phase, full wave bridge, using diodes without fuses, resistors or capacitors. Each bridge arm shall comprise two diodes in series. Each diode shall be rated for at least twice the maximum working voltage and current. All rotating components shall be proven at values of centrifugal stress under normal operating levels and fault conditions.

3. The automatic voltage regulator shall be capable of maintaining the steady state voltage with ± 1% of the controlled value over the whole load range of the generator for power factors between 0.8 and 1.0.

4. The excitation system shall be sufficient to cover any peaking load condition that the generator is able to supply. The exciter rating shall be 130% of the excitation current required at the rated output of the generator.

5. The automatic voltage regulators shall be of the automatic solid state, continuously acting type, providing facilities for local and remote voltage adjustment with motorized potentiometers. The voltage setting range shall be ± 5% of the rated value.

6. Failure of the operating regulator shall immediately cause the standby regulator to take over with negligible disturbance to the generator operation.

7. The stator, rotor and exciter windings shall have Class "H" insulation and shall be limited to Class “H” temperature rise.

2.04 Control Panel

A. **Cabinet**

1. Heavy gauge, 2.5mm thick, sheet steel construction, totally enclosed, dust and water protected and vermin proof to IP 55.
2. A hinged, lockable door shall give access to control and instruments.

3. "Live" parts shall be secured to prevent inadvertent contact with them.
4. Controls for diesel engine, alternator, exciter, meters and alarm device shall be positioned to give ample space for removing and installing components.

B. **Engine-Generator Control Panel:**

The engine-generator control panel shall be of the electronic modular type utilizing environmentally sealed, solid state, micro-processor based modules for engine control and AC metering. The panel shall be capable of operating under the operating temperature range of 0 degrees to +70 degrees Celsius. The electronic control system shall employ solid-state transducers for constant monitoring of oil pressure and coolant temperature through a Single Sire Serial Data Link. Unless otherwise specified in the Project Documentation, the control panel shall provide the following features:

1. Automatic start/stop engine control with programmable safety shutdowns and associated flashing LED indicators for low oil pressure, high coolant temperature, over speed, over crank and emergency stop.
2. Adjustable 1 to 60 second cycle cranking with rest periods.
3. Cool-down timer, adjustable between 0 and 30 sec.
4. LCD digital readout for:
    - engine oil pressure (N/mg)
    - lubricant oil pressure gauge (N/mg)
    - cooling temperature (0C)
    - exhaust gas temperature gauge (0C)
    - exhaust turbo-blower pressure gauge (N/mg)
    - engine RPM
    - system DC Volts
    - engine run hours
    - eight system diagnostic codes
    - generator AC Volts
    - generator AC Amps
    - Generator frequency
    - Stator winding and driver and generator bearings temperature monitoring unit.

It shall be of the flush fronted, door mounting type and provide a selectable digital readout for each of the temperature detectors. Alarm and trip contacts shall be provided in the form of volt free changeover contacts

The system diagnostic codes shall be designed to enhance the system protection and to allow for trouble shooting by untrained personnel.

5. These signals shall be:
   - loss of engine speed
   - invalid engine control switch
   - internal circuit fault
   - loss of coolant temperature
   - loss of data sending unit

6. These panels shall be provided with the following controls:
   - engine control switch
   - ammeter -voltmeter phase selection
   - emergency stop
   - indicator/display test switch
   - voltage adjustment

7. The minimum DCS interface signals shall be provided as follows :
   - Fuel oil high level
   - Fuel oil low level
   - Ready to start
   - Not available to start
   - Failed to start
   - Running
   - Load accepted
   - Common fault
   - Common trip

8. A proprietary annunciator system shall be utilized for visual and audible display of alarms and shutdowns.

   The generator control panel shall include, but not be limited to the following indication and alarms:

   - Fuel oil high (day tank) - alarm and indication
   - Fuel oil low (day tank) - alarm and indication
   - Ready to start indication
   - Not available to start indication and alarm
   - Stopped indication

- Generator fail to start alarm
- Electric priming pump failure alarm
- Battery charger alarms
- Driver coolant low level alarm
- Driver coolant temperature high alarm and shutdown
- Driver lubricating oil temperature high alarm and shutdown
- Driver lubricating oil pressure low alarm and shutdown
- Driver lubricating oil filter blocked alarm
- Driver over speed alarm and shutdown
- Mains supply available indication
- Generator supply available indication
- Generator supply on load indication
- Electrical trip alarm and shutdown
- Generator over voltage alarm and shutdown

9. Panel Wiring:

   a. All wiring of battery charger, exciter and control panel shall be P.V.C tropical grade of adequate current carrying capacity to prevent over-heating under worst climatic conditions.

10. Terminal Board:

   a. Terminal boards shall have pairs of terminals for Incoming and Outgoing wires and not more than two wires shall be connected to any one terminal.

   b. Insulating barriers shall be provided between adjacent connectors. Labels for wiring designation marks shall be provided on the fixed portion of the terminal boards as well as wires. No live metal shall be exposed at the back of the terminal boards.

   c. Terminal boards having pressure type terminal lusts or equivalent shall be used so that no terminal clamp is necessary. 10% spare terminals shall be provided for each terminal board assembly.

1.03 Terminal Boxes

A. The ends of the generator stator winding for mains connections shall be brought out to the generator terminal box.

B. Terminals and connections shall be continuously rated for 110% of the full load current of the generator.

1.04 Temperature Monitoring

A. A minimum of six, two per phase, embedded resistance temperature detectors in the stator winding shall be provided with the connections brought out to a separate terminal box. These shall be the platinum resistance thermometer elements, resistance 100 ohms at 0 degree Celsius, be the 3 wire type and have a minimum dielectric strength of 3 kV.

B. Generators shall be provided with local bearing temperature indicators and two thermocouples per bearing to monitor bearing temperature.

1.05 Vibration Limits

A. The Diesel Generator set shall have a maximum individual effective vibration velocity, measured on the bearing housing, not exceeding 2.8 mm per sec as per class IVA in accordance with ISO 2372

1.06 Noise Limits

A. Sound level shall not exceed 85 dB(A) at 7 meter from the end of the exhaust pipe.

1.07 Earthing

A. The generator terminal boxes shall be provided with M12 external earth studs.

B. The generator frame and base frame shall be provided with an M12 external studs.

C. All metallic non-current carrying parts that are not inherently bonded together shall be bonded to the frame earth.

D. Connections from the main earth bar to components shall consist of copper strips or green/yellow PVC sheathed stranded copper conductors. Termination lugs shall be of the compression type.

1.08 Shop Test

A. Complete engine-generator sets shall be shop tested in the factory prior to shipment. Four copies of the completed certified test record shall be submitted to the Engineer within 30 days after the completed test.

B. These tests shall be sufficient to assure that the units shall operate successfully and meet all operational requirements. All consumable items, test

and recording equipment shall be furnished by the manufacturer for these tests.

C. Each and every automatic shutdown devices; interlock arrangement shall be tested to the full satisfaction.

D. The shop test shall consist of but not limited to four continuous hours of operation. During the test, half hourly readings shall be recorded for the following items:

1. Time
2. Ambient temperature
3. Volts per phase
4. Current in each phase
5. Total kW

(6) Power factor

(7) Frequency

(8) Engine jacket temperature

(9) Cooling water temperature (in and out)

(10) Intake manifold pressure

(11) Lubricating oil pressure

(12) Intake manifold temperature

(13) Exhaust gas temperature

(14) Liters of fuel consumed per hour compared to generated kWhr

E. After completion of all testing, the following is required:

All entrapped water shall be drained, and proper protection applied to prevent entry of water or dust during shipment and transportation or storage.

The factory shop test should be witnessed by Three(3) MEW engineer. (2 from ESD, 1 from water dep.) All expenses incurred by the ministry engineers during the factory shop test which include fares, accommodations, allowances, etc. shall be borne by the tenderer.

1.09 Spares

A. Provide spare parts that are identical to and interchangeable with similar parts installed.

B. Provide recommended spare parts for 2 years of standby operation of each Genset and one tool kit.

C. The Contractor shall include in his offer, a detailed list of the manufacturer's recommended spare parts for a period of two years and all test equipment required, for trouble free maintenance of the proposed system.

PART 3 - EXECUTION

3.01 Installation

A. Product Delivery, Storage Handling:

1. Lift all Diesel Generator equipment-using eyes, yokes and skids provided by the manufacturer.

2. Do not store equipment assemblies exposed to weather.

3. Physically protect all generator equipment against damage from work of other trades.

4. Cover all generator equipment with suitable material to avoid damage to finish.

5. Contractor shall submit the calculation to prove the adequacy of capacity of the crane he intends to use for installation of the Diesel Generator set.

B. Installation:

1. The engine and generator shall be properly aligned and mounted on a common steel base through resilient mountings to prevent vibrations Foundation and other builder's work shall be as recommended by the manufacturer and approved by the Engineer.

2. Except as may be described in this Section or shown on the drawings carry out installation strictly in accordance with the manufacturer's recommendation.

C. 415 V switchboard:

1. Install, test and commission the 415 V switchboard as indicated on the drawing and as per its specifications.

2. Install, test and commission the neutral system including resistors and system earthing.

D. Power, control, signal and data cable-works:

1. Run, connect, test and commission the cable-work from generator to switchboard, and other equipment.

E. Control Boards:

1. Run all outgoing cables from the generator to the control boards in the floor trench as indicated on the Project Drawings.

F. Record Print:

1. Fix record print of each Diesel Generator set, framed behind non-glare plexiglass, on a wall near the generator control room.

3.02 **Paint Work**

A. Paint work of each set shall be of the highest quality to withstand the worst weather conditions specified. All steel works such as tanks, pipes, frames, louvers, ladders, platform, etc. shall be given two undercoats of anti-rust paint and two enamel finishing.

3.03 **Initial Test**

A. Each unit shall be tested in the contractor's facility prior to installation in the site.

B. The following test procedure shall be followed at 0.8 p.f.:

1. The generator shall be started and operated at 25% rated load for a period not less than $^1/_2$ hour, after which the load shall be increased to 50% of rated load and operated for the second $^1/_2$ hour.
2. The load then be increased to 100% and held continuously for a period not less than three hours. Then a 110% load will be applied for a period of one hour.
3. After the above operation, the generator shall be unloaded and run under no-load condition for at least 15 minutes.
4. A full 100% load then be applied and held for a period of not less than 15 minutes and not more than 30 minutes. The generator shall be loaded and un-loaded (On/Off operation) at 100% in this manner for a minimum of three operations, during which the speed load recovery capabilities of the unit shall be observed and report
5. All generating set protection devices shall be tested for proper operations.
6. After this initial test, the generating set shall be operated continuously for a period of 24 hours at 80% load, during which operational log sheet shall be conducted.

3.04 Field Test

A. Upon completion of the installation and as soon as condition permits, the standby power supply system including the engine driven generators, interlocks, electrical circuits, control, automatic and manual transfers and other devices shall be tested in presence of the Engineer, by the Contractor and the service representative of the manufacturer to assure the system functions as specified. All arrangements and costs incurred by such a test shall be responsibility of the sub-contractor

B. Prior to scheduling the test, the Contractor shall notify the Engineer in writing that all requirements and provisions of the Contract Documents have been met, that all equipment are adjusted and ready for operation and that instruction and operation manuals have been submitted.

C. The test shall consist of 4 hours of continuous operation of the unit at complete site load. During the test, all readings as were taken during shop test shall be recorded at 30 minutes intervals and compared.

D. As part of field test, each of the automatic shutdown devices shall be tested and respective values recorded. Any adjustment required shall be made only on recommendation of the engine manufacturer and recorded.

E. Additional tests shall be performed to demonstrate the standby system's ability to meet the automatic starting, synchronizing, load transfer and motor starting requirements as required.

3.05 Training of Operation and Maintenance Personnel

A. The Contractor shall train a number of six Engineers who will be selected by the Engineer for the operation and maintenance of all the works within the Project before these works are handed over to the Engineer (2 from ESD, 2 from water dep. And 2 from Tech. services dep.) and 24 technicians equally divided between the three MEW departments.

B. The training shall include classroom discussion on the theory of operation of the equipment, as well as maintenance and service methods for the purchased equipment. Topics covered shall include safety, hardware layout and functions, power & control wiring, diagnostic indicators, keypad/display interface, software mapping, programming, setup, configuration, control loop tuning, operational indicators, faults, diagnostic tools, troubleshooting, and preventive maintenance. Hands-on training shall be provided on equipment of the same design as that provided. Documentation shall be provided which shall include actual manuals for the equipment and drawings and schematics of equipment supplied for this project.

C. The training has to be carried out by qualified staff of the Contractor for each specified service and shall be provided for one month period following the Certificate of Completion.

17. DIESEL GENERATORS

MUTLA OLD CONTROL ROOM

1. SCOPE OF WORK

Design Supply, install, commission, test, operate, maintain and repair with spare parts for two years and handover in good working condition of the following:

1.1 Provide One (1) nos. 1,020 KW/ 1,275 KVA, 415 V, 1500 rpm, 0.8 P.F, 50 Hz generator sets Prime rated capacity inside Original Manufacturer weather prove ISO enclosure.

1. Fuel Underground Tank for 3 Days
2. Duplex fuel Transfer pump electrically operated with a capacity of 4 times the full load fuel consumption of the D/G set, complete with panel and Fuel transfer pump manually operated.
3. Two years extended warranty.
4. Load managing system.
5. Testing complete done at both, D/G manufacturer's premises and at the site.
6. Remote monitoring of engine and generator parameters on real time basis via communication network

The entire work shall be carried out in strict accordance with this specification, D/G drawings and latest regulation/requirements/specifications applicable to such works from government authorized institutions (like M.E.W./ K.F.S.D /KNPC etc).

The general conditions of the contract and any special conditions shall be applied to the D/G installation and any part thereof, in as far as they are applicable.

The contractor shall establish full co-ordination with the owner (M.E.W.) during the execution of work.

The contractor shall submit all required samples, technical details, catalogues in English language, shop drawing and any other necessary details, drawings etc. for approval by M.E.W. engineer prior to starting of any works. All expenses incurred during the design stage and implementation of works in the factory shall be borne by the tenderer including fares, accommodation, and etc. of ministry engineers visiting the factory.

All works (Engine, Alternator, Enclosure) shall be done in factory located in USA/Europe only. The completed generator package shall be factory tested first before shipping to M.E.W. The manufacturer shall submit certificates or any supporting documents that all the above mentioned works were done in factory.

1.3 415V Load Management System:

The Contractor shall provide with his offer preliminarily design for Load Management System Complete with Drawing, Catalogues failing of which offer shall be technically rejected

Load Management System shall be supplied and installed by the Diesel Generator supplier and under his scope, preferred to be the same manufacturer of diesel generator, UPS and ATS.

The approved manufacturer for Load Management Control System shall be the following:

9. SCHNEIDER
10. JOHNSON CONTROL
11. GENERAL ELECTRIC
12. ABB
13. CATERPILLAR
14. EATON
15. TERBERG
16. Any Other supplier approved by the manufacturer of Diesel Generator.

1.3 All required and necessary 415 V cable.

1.4 All required and necessary control cables.

1.5 All required and necessary civil works such as concrete foundations, cable, ducts, manholes, trenches for cables.

1.6 All required and necessary control system and modification of existing control system.

1.7 All required and necessary modification to connect ATS with MLTB complete with all required cables, control and sensors to complete the work in operation condition.

1.8 Design, supply and install complete underground diesel tank with all piping, wiring and accessories as per KNPC and KFD suitable for running all generators for 3 days at full load.

1.9 Training of the MEW staff.

1.10 All other requirement to complete the works in an operating condition to the acceptance of MEW.

1.11 The contractor shall operate, repair and maintain the Diesel Generator for a period of two years after handing over.

1.12 During the test of diesel generator the contractor shall supply diesel fuel.

1.13 During operation and maintenance MEW shall supply only diesel fuel,. Other materials required for maintenance of desired generator such as oil filters, spare parts etc. shall be supplied by Contractor.

1.14 voltage dip shall not exceed 10%.

1.15 The tenderer is required to visit the site of the work under the contract thorough out investigate the existing condition and fully account for all such works. Claims for additional payment on account of such work overlooked by the Tenderer at the time of pricing the tender shall not be entertained.

1.16 All other required items mentioned in the BOQ, specifications and drawings to complete the works in a satisfactory operation condition.

B. DIESEL GENERATOR SETS

General

1.01 **General Reference**

1. The work mentioned in these specifications is integral with the whole of the Project Documentation and is not intended to be interpreted outside that context.

2. Co-ordinate the work with all other services affecting the Gensets work.

1.03 Description of Work

A. Furnish all labor, materials, and equipment to install, place in operation, and field test the diesel generator sets. The complete generating sets shall be assembled by the generator manufacturer. Complete generator set shall be shipped to Kuwait and ready for installation at designated site. The diesel generator set shall be mounted on sufficient concrete foundation inside the generator room.

B. The diesel generator sets shall be rated prime including associated, control panels and other equipment, as per the Project Documentation.

C. The equipment to be furnished under this Section generally includes but not limited to the following:

1. Diesel engine driven generator sets

13) Electric cabling for power, control and communication between different panels and DG Sets
14) Air circuit breaker (sufficient capacity) with panel and bus bars for load connection point on the side of the enclosure and shall have a weather proof cover.
15) LV switchboards
16) Control panel, load transfer and load management panels as per specifications.
17) Cooling system including radiators and water piping connections
18) Exhaust systems
19) Fuel system bulk tanks, fuel piping, fuel transfer system and appurtenances.
20) Engine mounted electric starters, battery and battery charger.
21) Spare parts and special tools
22) Services of manufacturer's representative.

D. The Diesel Generator sets shall fully comply with all relevant contractual requirements specified in Scope of Work.

E. The Diesel Generator sets shall be arranged for either automatic or manual start on mains failure, as indicated on the Project Drawings.

1.03 Quality Assurance

A. Manufacturer's Qualification:

1. The Diesel Generator set (both Engine and Alternator) shall be the product of a single manufacturer regularly engaged as a manufacturer of such equipment. The Diesel Generator set should listed in the list of approved product brand by the Ministry of Electricity and Water.

B. Installer's Qualification:

1. All the Diesel Generator installation work shall be carried out by specialized Diesel Generator contractor. Diesel Generator contractor shall be one who is an authorized Dealer representing one of the approved makes of D/G sets. Diesel Generator installation shall be supervised, checked and tested by a qualified Dealer of the manufacturer and handover the works in perfect running order to the satisfaction of the Engineer.

C. Local Agent:

The manufacturer should have a Dealer in Kuwait who is well experienced in installation and maintenance of diesel generators of the size specified herein. The agent should have been associated with the manufacturer for a minimum period of Ten years.

D. Design Criteria:

1. All materials and equipment shall comply with relevant IEC and BS specifications or equivalent as regards quality of materials, performance and proving tests.
2. The emergency power supply system and its components shall be such as may be properly maintained and serviced without the necessity of carrying expensive spare part stocks, or being subjected to interrupted service due to the lack of spare parts.
3. The generator set shall be designed to allow easy replacement of major items subject to wear.

E. Responsibility:

Compliance with this specification shall not relieve the Contractor of responsibility to supply equipment suited to meet the specified service conditions and applicable regulations.

F. Conflict:

Where conflicts exist between this specification and other drawings, standards, codes and specifications, the most stringent shall be applied.

G. Other standards:

Equipment may comply with other National Standards subject to receipt of prior written approval from the Engineer.

1.04 Service Conditions

A. The equipment shall be suitable for continuous operation at a desert location under high ambient temperatures and humidity. The atmosphere at the Facility is generally dusty and corrosive

B. The Diesel Generator sets shall be new and in all respects suitable for operation under the service conditions stated in the Project Specification

C. The indoor or outdoor location and the type of weather protection required, eg, sun-shade structure, shall be as shown on the drawings.

D. Reliability of all equipment to perform continuously in the service conditions specified is essential. Equipment typical of that being supplied shall have been in operational use elsewhere in the similar climatic conditions for a minimum of two years. Prototype or unproven equipment not having a well-established record shall not be considered.

E. The rating of the generator sets shall be their Net output ratings after suitably derating, if applicable for the specified service conditions.

1.05 Basic Engineering Information

A. The Diesel Generator set shall be suitable for supplying power under Site conditions. The voltage, kW and kVA rated output as shown on the Single Line Diagram. The rated output shall mean the net full output for prime operation duty in Kuwait at ambient temperature up to **55 degree** Celsius at relative humidity 95%.

B. The set shall also be capable of running at 110% of rated capacity for one hour in every 12 Hours, under these conditions, at the rated speed without undue heating of the engine or alternator and without mechanical or electrical troubles.

C. The design shall be suitable for automatic remote start and shall be ready for operation at all times.

D. The Diesel Generator set shall be capable of accepting the connected loads in sequence and shall maintain the voltage and frequency tolerances specified in this specification.

E. The driver governor and fuel control system shall be designed such that no external power sources are required for their operation; that is, the driver must be capable of starting, running and stopping when all power supplies other than the battery supplies, have failed.

F. Electrical components for incorporation into the equipment shall comply with the relevant IEC standards. These shall be selected to exclude readily combustible insulating and constructional material and excessive heat generation; electrical and mechanical reliability is of the utmost importance.

1.06 Operating Philosophy

A. General:

1. Outline of plant operating philosophy for the Stand-by generator sets are given below: Final operation philosophy shall be discussed and agreed upon by engineer before ordering and start of manufacturing of control panels.

B. Normal status:

1. Diesel Generator sets shall normally be on standby and available for automatic instant start-up and switching ON of the appropriate circuit breakers on receipt of a remote signal or manual control. When at rest, those parameters which affect its availability to start and operate shall be continuously monitored and if a malfunction occurs, suitably alarmed at the generator control panel situated adjacent to the generator set and communicated to the remote control room.

C. Automatic start

1. When a loss of normal power occurs and provided automatic mode is selected, the generator set shall be started automatically by means of an under-voltage signal from the electrical distribution system.
2. A test facility shall be provided to simulate the under-voltage signal.
3. Interlocking system shall be initiated to prevent paralleling of MEW power sources; prior to connection of load.

D. Manual start

1. Provided the manual mode is selected the generator set shall be capable of being started manually by means of a local initiation and also from remote control room. When running in this mode a normal power failure shall result in an automatic connection of the generator to the switchgear bus bars.

E. Test mode

1. Starting of the Diesel Generator set shall be by manual means. This mode shall be used for engine exercising and test running operations.

F. Shutdown

1. Shutdown of the Diesel Generator set shall be manual from either the local generator control panel or remote shutdown switch.
2. The Diesel Generator set shall automatically shut down on malfunction of its essential auxiliary systems.
3. Emergency and mechanical shutdown facilities shall be provided.
4. Provision shall be made for remote emergency shutdown.

G. Remote operation and monitoring

13) Communication modules and facilities to start and stop each unit through a personal computer at local panel and also from DCS including monitoring of engine and generator parameters on real time basis via communication network shall be included.

14) Provide all necessary hardware and window-based/ equivalent software to be included.

1.07 System Responsibility

A. The standby Diesel Generator sets, generator switchboards and load switchboard shall be interconnected. The supplier of the generating system shall co-ordinate, study the loading scheme, include interlocking as necessary to achieve the requirements as shown on the drawing and as required to provide a system to prevent the generating system from stalling or faltering due to momentary or temporary overloads beyond system rating, from distribution faults, motor starting loads.

B. Co-ordinate and include interlocks with the MEW source supply to prevent parallel operation of standby generator supply with MEW supply.

1.8 Submittals

A. Shop Drawings:

1. Submit 3 Sets of shop drawings for approval.
2. Shop drawings shall be complete, as to be record drawings, not general outline drawings used for sales and guide layouts.
3. Submit a complete wiring diagram for the Diesel Generator set, drawn on a single standard size sheet, showing the following:

All components of:

- engine starting control
- engine alarm
- generator control
- battery
- battery charger
- Earthing
- transfer switch control relays

4. Interior wiring, terminals and interconnecting wiring
5. Certified dimensions and weights.
6. Submit a composite wiring diagram of the entire emergency transfer system showing all wiring between the engine starting panel, engine

generator set, control panel, LV Switchboard, Automatic transfer Scheme and Load panels etc.

7. Wiring diagrams shall clearly show:
   a. main current conductors, in heavy lines
   b. control conductors, with colour and/or number coding
   c. location of relays and apparatus
   d. description of function, type and catalogue, of all components.
8. Alternator Control Panel:
   a. submit a schematic line diagram showing:
      - Interlocks
      - Protection
      - Instruments
9. Submit general arrangement drawings of the generator installation and the generator container layout.

B. Following Product Data shall be submitted to engineer.

1. Submit the detailed information together with manufacturer's catalogues for the following:
   a. Generating set manufacturer
   b. Name and Address
   c. Generating set Model No.
   d. Radiator
   e. Fuel system
   f. Starting battery
   g. Control panel
   h. Service facilities
2. Test Certificates
3. List of Spare Parts recommended by Genset manufacturer.
4. Certified Factory Test Reports
5. Instruction Manuals for Operation and Maintenance
6. Parts Catalogue with Manufacturer address.

1.9 Period of Maintenance

A. During the specified maintenance period the sub-contractor shall repair and replace directly, at his own expense, any of the plant, material or work performed or furnished under the respective works in the Project which may develop under the conditions provided for by the Project and under proper use

in the works or that portion thereof taken over by the Engineer. The guarantee period for all electric motors shall be 2 years.

B. The sub-contractor shall obtain and submit to the Engineer all guarantees or certificates or warranty available from the manufacturers, but only as supplementary to the sub-contractor's own liabilities under the Project and in no way invalidate them.

C. The Diesel Generator sub-contractor shall be responsible for the satisfactory operation of the Diesel Generator set during the Maintenance and Guarantee Period. He shall carry out necessary inspection, preventive maintenance and testing to keep the set ready all the time. The set shall function satisfactorily during power failures. The Diesel Generator sub-contractor shall carry out routine testing of the installation once in every month throughout the Maintenance and Guarantee Period. The testing shall be carried out in presence of the Engineer. The Sub-contractor shall himself provide all electrical and mechanical spare parts, grease, lubricating oils, touch-up paints, etc., required for the maintenance of the Diesel Generator set installation. The Ministry shall be responsible only for providing diesel oil as and when required. The Diesel Generator sub-contractor shall prepare logbooks, list full details of maintenance work and each logbook entry shall be countersigned by the Engineer.

PART 2 – PRODUCTS

2.03 Diesel Generator Set

A. Generator sets shall include, but not be limited to the following:

1. Driver complete with auxiliary systems as detailed in here.

2. Generator and auxiliaries including brushless exciter and automatic voltage regulator.

4. Base frame.

5. Fuel systems and tanks.

6. Platforms and ladders for access, if required.

7. Control panel and battery charger units.

8. All associated piping, supports and consumable items.

B. Generator set assembly

1. The generator set shall be of the direct-coupled type without gearbox. The coupling shall be of the flexible type.

2. The complete assembly shall be mounted on a common base frame and shall be furnished with all necessary auxiliary equipment.
3. The assembly shall be completely pre-wired and piped requiring only connection of utility services to be operational.

C. **Base frame**

1. The generator set shall be mounted on a single steel base frame.
2. The base plate shall be a fully welded design of rigid construction suitable to support the weight of the components and withstand any unbalanced forces or tangential loads that may occur due to generator set running, thermal expansion or forces due to transportation or maneuvering during installation. The whole unit shall be fitted with anti-vibration mounting pads.
3. The base plate shall be constructed in such a way that it will not interfere with maintenance and routine servicing of the generator set, and shall be fitted with lifting and pulling lugs to facilitate installation and handing. A drip pan shall also be provided.
4. Adequate bonding conductors between the equipment and the base plate shall be provided together with two diagonally located earthing bosses on the base plate.
5. Anti-vibration mounts will normally be located under the base-frame. Isolators shall be of totally enclosed design, suitable for the environment, and possess an isolation efficiency of at least 80% in respect of all engine induced vibrations.

D. Acoustic soundproof Container (Enclosure)

A factory custom built acoustic soundproof enclosure shall be built to house the generator set by Genset Manufacturer for the above mentioned generator package. The manufactured enclosure shall meet the specification and standard of any relevant authorities or association (ISO, etc.) of the place where the enclosure is manufactured. The generator container shall be mounted on a concrete pedestal of sufficient concrete foundation on the designated site.

It shall be custom built fully weather proof and acoustic sound-proofed enclosure. It should be extremely rugged construction to withstand the extreme weather condition in Kuwait.

Air inlet and discharge flows are through sound attenuators positioned at container and constructed in splitter or baffle form to achieve effective noise absorption with minimum air resistance. Each sound attenuator incorporates

fixed blade weather louvers and bird guards. container shall have a lockable doors and these doors can be open during the extreme temperature to enhance the ventilation inside the enclosure..

The noise level shall be 85dbA @ 7 meter distance from the enclosure with the generator set operating at 100% prime rating when all doors are closed.

Emergency stop button shall be fitted also on the container.

The exhaust system employs critical exhaust silencer with pipe work lagged with a heat and sound resistant cladding material inside the container.
Lube oil, engine breather and cooling water drains piped to the exterior of the soundproof container.

A load connection point (terminal box) with weather proof access cover shall be provided on the container. The bus bars shall be enclosed in a weather proof cabinet and flexible cable of sufficient capacity shall connect the bus bars and the air circuit breaker.

2.02 Diesel Engine

A. Engine Performance

1. Engine performance shall be in accordance with the service conditions specified and provide continuously prime power rating at the Site during emergency outages with an overload power of 10% as per clause 1.06.
2. Rating of the diesel engine shall not be less than the sum of the following:
   a. Generator power requirement.
   b. Transmission losses (if any).
   c. Auxiliary power requirements for engine operation.

B. Engine Design and Construction

1. The engine shall be of the multi-cylinder, heavy-duty type, arranged in either in-line or V configuration, water cooled. Only 4 stroke engines are acceptable.
2. The engine shall be fitted with an over speed shutdown device.
4. The engine shall be fitted with the manufacturer's standard gauge and control panel; the instruments shall include a tachometer.
5. Engine speed shall not be greater than 1500 rpm.

C. Cooling System

1. The engine shall be furnished with a cooling system having sufficient capacity for cooling the engine when the diesel generator set is delivering 110% power at the service conditions specified.
2. The cooling system shall be of the closed circuit, circulating water type, which in turn shall be air-cooled by remote vertically wall mounted radiator or remote horizontal package with AC motor driven fans.
3. The cooling water system shall be fitted with an expansion tank and pressure relief valve and shall be self-venting. An opening shall be provided in the circuit for filling the system, checking coolant level and adding make-up coolant when required. All items shall be fully drainable.
4. The cooling water circuit shall be provided with thermostatic control of the engine coolant temperature. The temperature control shall be achieved by by-passing the radiator to a proportional degree by means of a thermostatic valve. Simple throttling of the coolant circulation is not permissible.
5. Engine mounted temperature indicators shall be provided to show the temperature of cooling water entering and leaving the engine cooling circuit.
6. A jacket water heater(s) shall be provided to maintain the cooling water at a suitable temperature for rapid starting and load acceptance. The heaters shall be thermostatically controlled and arranged to prevent local overheating.
7. The cooling water heaters shall be isolated when the engine reaches normal operating temperature.
8. The radiator shall be sized to dissipate the engine heat rejection to the water at 110% of the rated load. The radiator is rated at 55 deg C ambient and shall be supplied in accordance with the engine Approved Manufacturer's standard design.
9. Radiators shall be fitted with an adequately sized expansion tank and be complete with:
    a. level gauge
    b. low water level switch
    c. pressure cap
    d. vent
    e. drain
    f. earthing
    g. exhaust air ducting between radiator and wall mounted exhaust louver
10. In the case of fuel cooling, the Genset shall be equipped with fuel cooling system to withstand Kuwait's harsh summer weather condition at ambient

temperature up to 55 degree Celsius at relative humidity 95% and without effecting the continuous operation of the Genset or shutting down.

D. **Fuel System**

1. The engine shall be supplied with a complete fuel oil system which shall include, but not be limited to, the following:

   a. Water and sediment trap with clean out drain.

   b. fuel feed pump with pressure relief valve.

2. Fuel feed pump suction strainers of the duplex type with replaceable cartridge elements and full flow transfer valve. The nominal filtration of the filter shall be as recommended by the engine manufacturer for satisfactory continuous operation of the engine fuel system and shall be capable of protecting the fuel pump from any entrained particles (sand, dust etc. resulting from the ambient conditions), that may be present in the fuel oil. The filter elements shall be capable of easy removal.
3. An actuated fuel isolation valve arranged for remote control shall be provided in the fuel line to the engine
4. Guards or protection for all exposed fuel lines
5. The engine shall be suitable for running on diesel oil no. 2 or latest as per KNPC specifications.
6. Daily Fuel Tank:
   a. Fuel supply to each engine shall be maintained by a separate day tank. Daily fuel tank shall be sufficient capacity for continuous run of 4 hours at full load, unless otherwise specified in the Project Documentation and subject to approval from KFSD. The daily service tank shall be manufactured from mild steel to a rectangular shape and shall be complete with the following minimum equipment and facilities: -
   b. Inspection cover
   c. vent/breather pipe
   d. filler pipe connection
   e. overflow connection
   f. drain valve and sump drain
   g. level switches to control fuel transfer pump
   h. level switches to operate high and low fuel level alarm circuits in the diesel alternator set control panel
   i. lifting lugs.

7. **Main Fuel Storage Tank**:

   a. The Contractor shall supply and install underground cylindrical diesel oil storage tank with sufficient capacity to operate the associated diesel generator set continuously on full load for 3 days, or as specified in the Project Documentation.

   b. The tank shall be welded mild steel construction suitably protected from corrosion and shall be installed in the location indicated on the drawings.

   c. The standard tank size in accordance with specification BS 2594, the minimum thickness of dished end, compartment plates and shell plates shall conform to the dimension given in table 1A of the specification BS 2594.

   d. The storage tank shall be complete with pipes, fittings, feed lines, vents. etc. The tank shall be of the approved underground type located outside the diesel engine room. The tank shall be provided with 600 mm inspection manhole with cover, 50 mm filling pipe with cooped filling terminal, 50 mm air vent pipe with screen outlets, isolating valve, valve drain etc.

   e. Electronic fuel indicator with an audio/visual alarm shall be provided for main fuel storage tank; include proper earthing for any static electrical charges to the filling system.

   f. Underground filling point (as per KNPC and KFSD regulations) with cover shall be provided. It shall be equipped with gate valve and 2.5 inches kamlock adapter for Diesel fuel tanker filling. Audio/visual level alarm shall be provided near the filling point.

   g. Also the storage tank and its accessories must comply with the Kuwait regulations for generator installations.

   h. The tank shall be approved for use by KNPC (Kuwait National Petroleum Company) and K.F.S.D

8. **Duplex Diesel Pumping Set:**

   a. Provide packaged type duplex, self-priming, fuel pumping and straining set with a capacity of four times the total fuel consumption of engine at full load. Pump sets shall be wired and tested. Pumps shall be activated by a switch in the day tank automatically. All pumps installed inside the generator room, shall be flame-proof and fire-resistant as per NFPA Regulations

   b. Piping shall be complete to suction, discharge and return line connections. Provide gate valves and unions arranged to permit removal of either pump while the system is in operation. Install check valves and relief valves on pump outlet and gate valves prior to pressure gauges

c. Suction strainer shall be flanged connection, duplex type, one-piece, cast-iron body, ASTM A48 Class 30, with 1.2 mm perforation brass baskets

d. Oil pump set shall be factory assembled on a structural steel channel beam base to include pumps, motors, flexible couplings and guards. Pump set shall be suitable for diesel oil

e. Suitable manually operated pump shall be provided.

9. **Tank Gauges:**

a. With gauges to indicate level of fuel in the tank. Also level sensor for continuous level measurement and High/low level contacts shall be provided. The switches and gauges shall be designed for operation from a 24 Volt DC, loop powered system.

b. Tank fittings and pressure fittings shall be made of solid bar stock to prevent leak possibilities.

10. **Diesel Oil Piping**:

a. Provide all diesel oil piping from storage tank to day tank fill lines, water tight fill boxes, vents, vent caps, tank foot valves, and accessories

b. Provide swing checks valves and gate valves at pump inlets. Provide approved anti-siphon valves at high points of suction lines. Provide whatever additional valves that may be required by local regulations

c. All piping shall be provided with ground joint unions at piece of apparatus to facilitate connecting and disconnecting

d. All piping, unless otherwise specified, shall be schedule 40 standard weight black wrought iron pipe

e. Steel vent pipelines shall run from the fuel oil storage tanks, carried to the proper height within building construction and terminating with vent fittings.

11. **Lubricating System**

a. The lubricating oil shall be of a type readily available internationally.

b. The lubrication system shall be positive displacement type. By-pass arrangement should be provided in case of filter clogging.

c. A heat-exchanger shall be provided for cooling the lubricating oil if necessary and this shall be of long-life type i.e. the system shall not require constant cleaning or other maintenance work. A valve for taking oil sample shall be provided. The coolant for the above shall be jacket water of the engine. That is, the cooling system of the engine and the lube-oil heat-exchanger cooling system shall work in parallel or in series.

d. If the lube-oil pressure reaches low value, the engine shall be shut down automatically and also immediately should give audible alarm together with visual indication. The lube-oil system shall be provided with means to monitor pressure at important points at the engine-monitor panel.

e. A large capacity oil sump shall be provided and incorporated in the construction of the bedplate.

f. The system of lubrication shall ensure that adequate oil is pumped to all rotating parts.

g. The system shall incorporate a level dipstick, filler cap and tube and crankcase breather pipe or outlet.

h. The capacity of the lubricating oil system shall be sufficient to enable the engine to run continuously for 12 hours at any load without replenishment.

i. Suitable manual-pumping arrangement for easy draining of the whole quantity of lube-oil into a drum shall be provided.

12. **Exhaust System:**

a. Exhaust pipes shall be of Schedule 40 black steel and of adequate size to ensure that backpressure does not exceed the value specified by the manufacturer.

b. The exhaust pipe shall be connected through airtight flexible coupling to the engine.

c. Exhaust pipes shall be adequately lagged with 75mm thick (minimum) rock wool covered with aluminium sheaths of minimum thickness 1.5mm so that to take care of exhaust gas temperature in pipes exceeding 500^0C. When exhaust pipes pass through walls or roof a suitable weatherproof sleeve or thimble shall be provided to isolate exhaust pipe from the building. A silencer of heavy duty residential type shall be provided in the exhaust system and it shall also be lagged. The operation of casting the sleeves in the concrete, if required, will be carried out by a civil contractor.

d. Exhaust pipes and silencers shall be supported from the ceiling by special
vibration isolating hangers and the pipe shall be slanted away from the engine and a condensate trap fitted at the lowest points. Approved rain caps shall be installed at the discharge end of the exhaust pipes on the roof.

e. Suitable flexible expansion joints shall be provided along the pipe run to take care of expansion requirements.

f. The completed exhaust system shall be capable of limiting the noise level at the external outlet to 85 dB (A) at seven metres from the end of the exhaust pipe.

g. Suitable guards shall be provided with the exhaust pipe to prevent small animals/reptiles from entering.

13. **Filters**: Cleanable/replaceable elements should be provided.

a. Fuel Oil System - The system shall have the following filters fitted before the fuel injection pumps:

- A primary fuel filter of ample capacity to prevent all particles of 10 microns size or smaller.
- A secondary filter to prevent all particles down to 3 microns size or smaller.

b. Lubricating Oil System - This system should have full flow filters of sufficient capacity

- Tenderers shall give full particulars of the filters used. It shall be mentioned in if filter elements are cleanable for replaceable, in which case, the working hours after which the element and the Lubricating oil is to be replaced should be stated.

c. Intake and Exhaust System - Air is inducted to the engine manifold through

- Large capacity air cleaner
- Both filters are required due to severity of dust storms and dust suspensions in the air
- The engine exhaust line shall be fitted with flexible fitting efficient silencer to give efficient silencing with minimum backpressure and terminated outside the acoustic soundproof enclosure.

14. **Ventilation**:

a. The following ventilation works are required for the diesel engine generator
room.

- Louvers and sand filters shall be provided in the generator room to meet the generator manufacturer ventilation requirements.
- Necessary ventilation design and arrangement shall be considered and provided to meet the total ventilation requirement of the generators.

15. **Governing System**:

a. The governor should be of the electronic type.

b. The engine shall run steadily at any load within its rating at its rated speed, and the changes in speed due to change in load shall be

suitable for isochronous and droop control, and for local/remote speed adjustment..

c. The engine shall be provided with a governor with paralleling capabilities to enable the generator to operate in parallel with other generators.

16. **Coupling and Common Bed**:

a. The engine and the alternator shall be suitably coupled directly without interposing gear arrangement.

b. The common bed shall be provided with spring type anti-vibration mountings devices for fixing to the floor.

c. The engine vibration shall be the minimum possible and shall comply with the relevant BS. The vibratory force induced as the engine passed through resonance revolutions during starting and stopping period shall not cause any damage to the whole system.

E. **Starting system:**

The diesel engine shall be equipped with starting system detailed hereunder and as per Engineer's approval.

1. Battery Starting System:

a. Electrical engine starting shall be by electric 24 V d.c. starter motor and lead acid battery system.

b. The automatic start sequence shall be arranged such that there are 6 cranking periods of 10 seconds maximum duration, interspersed with 6 rest periods. The automatic start sequence shall be locked out after six unsuccessful cranking periods. engaging with engine flywheel and positively dis-engaging on engine starting.

c. The engine starting control equipment shall be arranged to disconnect the battery charger to prevent it from being over-loaded during starting. The starter motor shall be of adequate power of its duty.

F. **Battery charger unit**

1. A sufficient capacity battery chargers(as per recommended by generator manufacturer) and associated distribution equipment shall be housed in free standing or wall mounting sheet steel enclosures with a degree of protection not less than IP55 .

2. The set of starting batteries shall be located in ventilated sheet steel enclosures mounted on the generator set skid. Anti-vibration mountings shall be employed.

3. The battery boxes steelwork shall be insulated by means of plastic or epoxy coating to provide suitable protection against the effects of electrolyte spillage.

4. The batteries shall normally be on a continuous float charge, with the charger maintaining the batteries in a fully charged condition, at the same time supplying any continuous standby quiescent load. Each unit shall be rated for 125% of the maximum expected load. The ampere-hour rating of the batteries shall be suitable for the starting duty specified in the paragraph entitled Start System, under the minimum ambient temperature conditions.

5. The starting battery chargers shall be of the automatic solid-state type with constant voltage and current limiting characteristic. Manual boost and float charge facilities shall be provided. The charger shall be able to operate satisfactorily with the batteries disconnected. Boost charging shall only be used where the battery characteristic permits.

6. The r.m.s value of the ripple on the charger d.c. output voltage, with the battery connected, shall not exceed 5% or the value recommended by the battery manufacturer, whichever is lower. The charging voltage level shall be adjustable within ± 10% of nominal voltage.

7. Chargers shall include the following equipment :

    a. A.C. supply on/off switch
    b. Charge indication lamps
    c. D.C. voltmeter measuring charger output voltage
    d. D.C. ammeter with zero at mid-scale, measuring battery current
    e. D.C. ammeter measuring charger output current
    f. Fuses to protect battery charger circuits
    g. Battery fuse switch
    h. Battery charger fault

8. A separate charger shall be provided for each of the two sets of starting batteries. Each charger shall be sized to restore a fully discharged battery to 100% capacity within 8 hours. Battery charging shall be current limited such that isolation during cranking is not necessary.

9. Engine-driven alternators shall be provided to charge the starting batteries when the engine is running, the system shall ensure that battery charging is effectively controlled by diode steering.

10. Batteries shall be of the lead acid type. Plastic cell container material shall be non-flame propagating, mechanically shock resistant and translucent, to give a visual indication of electrolyte level.

11. Inter-cell connections shall be provided and shall be insulated or otherwise provided with protective covering to prevent inadvertent short circuiting.

12. Batteries shall be protected against the effects of over-voltage, under-voltage and overcharging in accordance with the battery manufacturer's recommendations.

13. Batteries shall be furnished in a dry condition with electrolyte liquid in separate container. Electrolyte shall be added at the time the battery is put into service and given a conditioning charge.

14. The control system battery/charger unit shall be of similar design and construction to the starting battery charger units. The battery capacity shall be adequate to support the standing load for 8 hours after mains failure and to provide control power to start the generator set after this time.

2.05 **Alternator and Exciter**

A. Generator

1. The generator shall be as per Prime rated duty. The minimum generator rating expressed in kilowatts when operating at rated voltage, frequency and power factor and connected to a virtually balanced load shall be in accordance with that specified on the Single Line Diagram.

2. The generator rated voltage and frequency shall be in accordance with that specified on the Single Line Diagram. The voltage waveform characteristics shall be sinusoidal and in accordance with the requirements of IEC 34-1.

3. The rated power factor shall be taken as 0.8 lagging.

4. The generator set shall be capable of supplying its rated output at rated power factor for voltage and frequency variation in the voltage range ±10% and frequency range ±5% occurring simultaneously.

5. The generator shall be capable of withstanding without damage a three phase, a line to line, a line to earth or two lines to earth short circuit for a period of 3 seconds when operating at rated speed and with an excitation corresponding to 5% over voltage at no-load.

6. The generator shall be capable of operating continuously at rated voltage and frequency on an unbalanced load, at rated current containing 8% negative sequence component.

7. The maximum level of the total harmonic amplitude shall not exceed 5% of the fundamental, while the maximum of any given harmonic shall not exceed 3% of the fundamental.

8. The generator shall sustain a minimum short circuit current of 300% of the generator rated current for minimum of 3 seconds.

9. The generator set shall be capable of operating continuously when supplying on Site harmonic services such as variable speed drive equipment.

B. Excitation

1. The excitation shall comprise of a direct driven rotary brush less a.c. exciter, a solid-state automatic voltage regulator, voltage adjustment facility and fault contact. The excitation system shall include a permanent magnet generator pilot exciter. The a.c. exciter shall carry a full wave rotating rectifier assembly, complete with surge suppression networks.

2. The rectifier bridge shall be three phase, full wave bridge, using diodes without fuses, resistors or capacitors. Each bridge arm shall comprise two diodes in series. Each diode shall be rated for at least twice the maximum working voltage and current. All rotating components shall be proven at values of centrifugal stress under normal operating levels and fault conditions.

3. The automatic voltage regulator shall be capable of maintaining the steady state voltage with ± 1% of the controlled value over the whole load range of the generator for power factors between 0.8 and 1.0.

4. The excitation system shall be sufficient to cover any peaking load condition that the generator is able to supply. The exciter rating shall be 130% of the excitation current required at the rated output of the generator.

5. The automatic voltage regulators shall be of the automatic solid state, continuously acting type, providing facilities for local and remote voltage adjustment with motorized potentiometers. The voltage setting range shall be ± 5% of the rated value.

6. Failure of the operating regulator shall immediately cause the standby regulator to take over with negligible disturbance to the generator operation.

7. The stator, rotor and exciter windings shall have Class "H" insulation and shall be limited to Class “H” temperature rise.

2.04 Control Panel

A. Cabinet

1. Heavy gauge, 2.5mm thick, sheet steel construction, totally enclosed, dust and water protected and vermin proof to IP 55.
2. A hinged, lockable door shall give access to control and instruments.
3. "Live" parts shall be secured to prevent inadvertent contact with them.
4. Controls for diesel engine, alternator, exciter, meters and alarm device shall be positioned to give ample space for removing and installing components.

B. Engine-Generator Control Panel:

The engine-generator control panel shall be of the electronic modular type utilizing environmentally sealed, solid state, micro-processor based modules for engine control and AC metering. The panel shall be capable of operating under the operating temperature range of 0 degrees to +70 degrees Celsius. The electronic control system shall employ solid-state transducers for constant monitoring of oil pressure and coolant temperature through a Single Sire Serial Data Link. Unless otherwise specified in the Project Documentation, the control panel shall provide the following features:

1. Automatic start/stop engine control with programmable safety shutdowns and associated flashing LED indicators for low oil pressure, high coolant temperature, over speed, over crank and emergency stop.
2. Adjustable 1 to 60 second cycle cranking with rest periods.
3. Cool-down timer, adjustable between 0 and 30 sec.
4. LCD digital readout for:
    - engine oil pressure (N/mg)
    - lubricant oil pressure gauge (N/mg)
    - cooling temperature (0C)
    - exhaust gas temperature gauge (0C)
    - exhaust turbo-blower pressure gauge (N/mg)
    - engine RPM
    - system DC Volts
    - engine run hours
    - eight system diagnostic codes
    - generator AC Volts
    - generator AC Amps

- Generator frequency
- Stator winding and driver and generator bearings temperature monitoring unit.

It shall be of the flush fronted, door mounting type and provide a selectable digital readout for each of the temperature detectors. Alarm and trip contacts shall be provided in the form of volt free changeover contacts

The system diagnostic codes shall be designed to enhance the system protection and to allow for trouble shooting by untrained personnel.

5. These signals shall be:
   - loss of engine speed
   - invalid engine control switch
   - internal circuit fault
   - loss of coolant temperature
   - loss of data sending unit

6. These panels shall be provided with the following controls:
   - engine control switch
   - ammeter -voltmeter phase selection
   - emergency stop
   - indicator/display test switch
   - voltage adjustment

7. The minimum DCS interface signals shall be provided as follows :
   - Fuel oil high level
   - Fuel oil low level
   - Ready to start
   - Not available to start
   - Failed to start
   - Running
   - Load accepted
   - Common fault
   - Common trip

8. A proprietary annunciator system shall be utilized for visual and audible display of alarms and shutdowns.

   The generator control panel shall include, but not be limited to the following indication and alarms:

   - Fuel oil high (day tank) - alarm and indication
   - Fuel oil low (day tank) - alarm and indication
   - Ready to start indication
   - Not available to start indication and alarm

- Stopped indication
- Generator fail to start alarm
- Electric priming pump failure alarm
- Battery charger alarms
- Driver coolant low level alarm
- Driver coolant temperature high alarm and shutdown
- Driver lubricating oil temperature high alarm and shutdown
- Driver lubricating oil pressure low alarm and shutdown
- Driver lubricating oil filter blocked alarm
- Driver over speed alarm and shutdown
- Mains supply available indication
- Generator supply available indication
- Generator supply on load indication
- Electrical trip alarm and shutdown
- Generator over voltage alarm and shutdown

9. Panel Wiring:

   a. All wiring of battery charger, exciter and control panel shall be P.V.C tropical grade of adequate current carrying capacity to prevent over-heating under worst climatic conditions.

10. Terminal Board:

   a. Terminal boards shall have pairs of terminals for Incoming and Outgoing wires and not more than two wires shall be connected to any one terminal.

   b. Insulating barriers shall be provided between adjacent connectors. Labels for wiring designation marks shall be provided on the fixed portion of the terminal boards as well as wires. No live metal shall be exposed at the back of the terminal boards.

   c. Terminal boards having pressure type terminal lusts or equivalent shall be used so that no terminal clamp is necessary. 10% spare terminals shall be provided for each terminal board assembly.

2.12 **Terminal Boxes**

B. The ends of the generator stator winding for mains connections shall be brought out to the generator terminal box.

B. Terminals and connections shall be continuously rated for 110% of the full load current of the generator.

2.13 **Temperature Monitoring**

A. A minimum of six, two per phase, embedded resistance temperature detectors in the stator winding shall be provided with the connections brought out to a

separate terminal box. These shall be the platinum resistance thermometer elements, resistance 100 ohms at 0 degree Celsius, be the 3 wire type and have a minimum dielectric strength of 3 kV.

B. Generators shall be provided with local bearing temperature indicators and two thermocouples per bearing to monitor bearing temperature.

2.14 **Vibration Limits**

A. The Diesel Generator set shall have a maximum individual effective vibration velocity, measured on the bearing housing, not exceeding 2.8 mm per sec as per class IVA in accordance with ISO 2372

2.15 **Noise Limits**

A. Sound level shall not exceed 85 dB(A) at 7 meter from the end of the exhaust pipe.

2.16 **Earthing**

A. The generator terminal boxes shall be provided with M12 external earth studs.

B. The generator frame and base frame shall be provided with an M12 external stud.

C. All metallic non-current carrying parts that are not inherently bonded together shall be bonded to the frame earth.

D. Connections from the main earth bar to components shall consist of copper strips or green/yellow PVC sheathed stranded copper conductors. Termination lugs shall be of the compression type.

2.17 **Shop Test**

A. Complete engine-generator sets shall be shop tested in the factory prior to shipment. Four copies of the completed certified test record shall be submitted to the Engineer within 30 days after the completed test.

B. These tests shall be sufficient to assure that the units shall operate successfully and meet all operational requirements. All consumable items, test and recording equipment shall be furnished by the manufacturer for these tests.

C. Each and every automatic shutdown devices; interlock arrangement shall be tested to the full satisfaction.

D. The shop test shall consist of but not limited to four continuous hours of operation. During the test, half hourly readings shall be recorded for the following items:

15. Time
16. Ambient temperature
17. Volts per phase
18. Current in each phase
19. Total kW
20. Power factor
21. Frequency
22. Engine jacket temperature
23. Cooling water temperature (in and out)
24. Intake manifold pressure
25. Lubricating oil pressure
26. Intake manifold temperature
27. Exhaust gas temperature
28. Liters of fuel consumed per hour compared to generated kWhr

E. After completion of all testing, the following is required:

All entrapped water shall be drained, and proper protection applied to prevent entry of water or dust during shipment and transportation or storage.

G. The factory shop test should be witnessed by Three(3) MEW engineer. (2 from ESD, 1 from water dep.) All expenses incurred by the ministry engineers during the factory shop test which include fares, accommodations, allowances, etc. shall be borne by the tenderer.

2.18 **Spares**

A. Provide spare parts that are identical to and interchangeable with similar parts installed.

B. Provide recommended spare parts for 2 years of standby operation of each Genset and one tool kit.

C. The Contractor shall include in his offer, a detailed list of the manufacturer's recommended spare parts for a period of two years and all test equipment required, for trouble free maintenance of the proposed system.

PART 3 - EXECUTION

3.01. Installation

A. Product Delivery, Storage Handling:

1. Lift all Diesel Generator equipment-using eyes, yokes and skids provided by the manufacturer

2. Do not store equipment assemblies exposed to weather.

3. Physically protect all generator equipment against damage from work of other trades.

4. Cover all generator equipment with suitable material to avoid damage to finish.

5. Contractor shall submit the calculation to prove the adequacy of capacity of the crane he intends to use for installation of the Diesel Generator set.

B. Installation:

1. The engine and generator shall be properly aligned and mounted on a common steel base through resilient mountings to prevent vibrations Foundation and other builder's work shall be as recommended by the manufacturer and approved by the Engineer.

2. Except as may be described in this Section or shown on the drawings carry out installation strictly in accordance with the manufacturer's recommendation.

C. 415 V switchboard:

3. Install, test and commission the 415 V switchboards as indicated on the drawing and as per its specifications.
4. Install, test and commission the neutral system including resistors and system earthing.

D. Power, control, signal and data cable-works:

1. Run, connect, test and commission the cable-work from generator to switchboard, and other equipment.

E. Control Boards:

1. Run all outgoing cables from the generator to the control boards in the floor trench as indicated on the Project Drawings.

F. Record Print:

1. Fix record print of each Diesel Generator set, framed behind non-glare plexiglass, on a wall near the generator control room.

3.02 **Paint Work**

A. Paint work of each set shall be of the highest quality to withstand the worst weather conditions specified. All steel works such as tanks, pipes, frames, louvers, ladders, platform, etc. shall be given two undercoats of anti-rust paint and two enamel finishing.

3.03 **Initial Test**

A. Each unit shall be tested in the contractor's facility prior to installation in the site.

B. The following test procedure shall be followed at 0.8 p.f:

1. The generator shall be started and operated at 25% rated load for a period not less than $^1/_2$ hour, after which the load shall be increased to 50% of rated load and operated for the second $^1/_2$ hour.
2. The load then be increased to 100% and held continuously for a period not less than three hours. Then a 110% load will be applied for a period of one hour.
3. After the above operation, the generator shall be unloaded and run under no-load condition for at least 15 minutes.
4. A full 100% load then be applied and held for a period of not less than 15 minutes and not more than 30 minutes. The generator shall be loaded and un-loaded (On/Off operation) at 100% in this manner for a minimum of three operations, during which the speed load recovery capabilities of the unit shall be observed and report
5. All generating set protection devices shall be tested for proper operations.
6. After this initial test, the generating set shall be operated continuously for a period of 24 hours at 80% load, during which operational log sheet shall be conducted.

3.04 **Field Test**

A. Upon completion of the installation and as soon as condition permits, the standby power supply system including the engine driven generators, interlocks, electrical circuits, control, automatic and manual transfers and

other devices shall be tested in presence of the Engineer, by the Contractor and the service representative of the manufacturer to assure the system functions as specified. All arrangements and costs incurred by such a test shall be responsibility of the sub-contractor

B. Prior to scheduling the test, the Contractor shall notify the Engineer in writing that all requirements and provisions of the Contract Documents have been met, that all equipment are adjusted and ready for operation and that instruction and operation manuals have been submitted.

C. The test shall consist of 4 hours of continuous operation of the unit at complete site load. During the test, all readings as were taken during shop test shall be recorded at 30 minutes intervals and compared.

D. As part of field test, each of the automatic shutdown devices shall be tested and respective values recorded. Any adjustment required shall be made only on recommendation of the engine manufacturer and recorded.

E. Additional tests shall be performed to demonstrate the standby system's ability to meet the automatic starting, synchronizing, load transfer and motor starting requirements as required.

3.05 Training of Operation and Maintenance Personnel

A. The Contractor shall train a number of six Engineers who will be selected by the Engineer for the operation and maintenance of all the works within the Project before these works are handed over to the Engineer (2 from ESD, 2 from water dep. And 2 from Tech. services dep.) and 24 technicians equally divided between the three MEW departments.

B. The training shall include classroom discussion on the theory of operation of the equipment, as well as maintenance and service methods for the purchased equipment. Topics covered shall include safety, hardware layout and functions, power & control wiring, diagnostic indicators, keypad/display interface, software mapping, programming, setup, configuration, control loop tuning, operational indicators, faults, diagnostic tools, troubleshooting, and preventive maintenance. Hands-on training shall be provided on equipment of the same design as that provided. Documentation shall be provided which shall include actual manuals for the equipment and drawings and schematics of equipment supplied for this project.

C. The training has to be carried out by qualified staff of the Contractor for each specified service and shall be provided for one month period following the Certificate of Completion.

18. MOTOR STARTERS:

18.1 Intelligent Motor Protection Relay:

Intelligent Motor protection relay shall be provided for each Motor Starter the following:

Protection for the following:

- Overload
- Phase short circuit
- Single phase / unbalance
- Over temperature
- Dry running protection (for pump motor)

18.2 Monitoring and metering the following and submit all the data to Building automation system:

- Status ON / OFF / TRIP
- Current
- Temperature
- Fault diagnosis.

1. Contactors employed for motor starting duty shall be of continuous duty rating, utilization category AC3 with type 2 co-ordination.
2. Each starter shall be provided with a set of ON and OFF push buttons, ON, OFF and TRIP indicating lamps and suitably scaled ammeter with selector switch for motor above 25HP.
3. Facilities shall be provided for alternative hand operation of automatically controlled starters.

18.2.1 Local control station

Motor valve shall be furnished with local control station with following apparatus:

- Lockable selector switch local – remote – off
- 3 push buttons for open – stop – close

The enclosure of the motor, switches and position indication shall be with double sealed comply with IEC No. 144 of Degree of Protection IP 65. The local control station shall be provided by Valve motor manufacturer.

18.3 **Motor Valve Control Panel:**

The motor valve control panel shall be furnished and wired by the manufacturer of the Valve Motor and shall incorporable the following:

Means of isolation from electricity supply for purpose of adjustment and maintenance.

MCB or Fuses suitable rating for short circuit protection.

Means for automatically disconnecting it from electricity supply in event of: -

a) Phase failure
b) Reverse phase sequence
c) Flow of excess current.

Earth leakage 300 mA

Push button for manually operation for Open – Stop - Close.

Lockable selector switch to operate the motorized valve manually by push button or automatically by external control signal or remote from Local Control Station near the valve motor and shall have off position.

Valve Position indicator meter.

18.4 Specification for Soft starters with bypass contactor

1. **Introduction**

1.1 This specification covers electronic soft starters, three-phase controlled, ie 6 thyristors (SCRs).

1.2 The starter provides power for starting and stopping three phases asynchronous motors (squirrel-cage) type IEC or NEMA. The stop will be of the type: freewheel stopped or ramp controlled.

2. **Quality of the product and of the Supplier**

2.1 The soft- starter shall be developed and qualified in accordance with international standards, particularly with the standard dedicated to soft-starter EN / IEC 60947-4-2.

2.2 The starter must be CE marked under the harmonized standard EN / IEC 60947-4-2.

2.3 In accordance to electromagnetic compatibility, the soft-starter must comply with Class A for conducted and radiated emissions, described in the standard EN / IEC 60947-4-2, and this for all the basic functions available within the soft-starter.

Class B can be obtained with additional accessories and covers only soft-starters with a rated current not exceeding 170 A.

2.4 The Soft-starter shall comply with UL 508 and CSA "Industrial Control Equipment

2.5 The manufacturing facilities for Soft-starters and associated activities such as development and design must be certified ISO 9001 version 2000 and ISO 14001.

3. **Description of the product**

3.1 The operating principle of the Soft-starter should not simply take ground on a limitation of motor current during the transitional phases or on a voltage ramp but on a torque control motor. The Soft-starter should provide a torque ramp during the acceleration phase. Thus, it can control the torque during the starting period and if necessary provide a motor torque constant throughout the acceleration phase.

3.2 For pumping applications, the deceleration will be on torque a ramp.

3.3 All Soft-starter sizes will have the same control boards related to the proper voltage. That control board must be identical for all applications. So the same Soft-starter can be used on a grinder, a pump or a conveyor (taking into account the sizing).

3.4 All Soft-starters shall be equipped with means for measuring motor current to ensure engine protection.

3.5 The terminals for the mains should be located top of the Soft-starter and the motor terminals will be bottom (through wiring).

3.6 The measurements of the current will be active when the Soft-starter is by-passed (embedded by-pass for all sizes).

3.7 The Soft-starter should have a separate power control.

3.8 The terminals of the board control shall be of plug type.

4. **Environnement**

4.1 The Soft-starter shall be able to operate in ambient temperatures from -10 to + 40 ° C without derating and between 40 and 60 ° C with derating of 2,2% per degree C above 40 ° C.

4.2 The maximum relative humidity will be 95% without condensation or dripping water according to standards IEC60947-4-2.

4.3 The storage temperature can be between -25 ° C to + 70 °

4.4 The maximum operating altitude is 1000 meters (3280 feet), beyond; the Soft-starter will be downgraded from 2% per 100 meters (328 feet).

4.5 The supplier will indicate a noise level of the Soft-starter; this noise level should not exceed 65 dBA.

4.6 About the Soft-starter cooling, if the Soft-starters are equipped with fans, those fans should not run continuously. They will be managed automatically according to the temperature of the heatsink.

4.7 The degree of environmental pollution will be a maximum degree 2 according to IEC 60664-1 (or IEC 60947-4-2).

4.8 The supplier will indicate the connection diagrams of the Soft-starters.

4.9 The supplier will make available the association charts between circuit breakers, fuses, contactors and Soft-starters in a way to ensure coordination of type1.

5. **Electrical characteristics of the Soft-starter**

5.1 The run category of the Soft-starters will be on a standard AC 53b following EN / IEC 60947-4-2.

5.2 The supplier shall be able to offer Soft-starters in one or several ranges in a way to cover mains from 208 to 600V (208 to 600 V -15% +10%).

5.3 The current range of Soft-starters will be between 17 and 590 A.

5.4 The Soft-starter will automatically adapt itself to the frequency of the mains 50 or 60 Hz with a tolerance of + / -10%.

5.5 Logic inputs: the Soft-starter should have at least 3 isolated digital inputs 24Vdc or 110Vac.

5.6 Outputs: the Soft-starter must have at least 2 relays with a NO/NC contact

Maximum switching capacity on inductive load: 2 A at 250 Vac and 30 Vdc. Minimum switching capacity 100 mA at 12 Vdc.

5.7 The soft-starter shall have its own 24Vdc source power supply or external 110Vac power supply for logic inputs

5.8 The supplier will offer an array of choices of Soft-starters for 2 types of design:- Sizing 1 : Starting from cold state (motor service S1): 1 start at 3,5 In for 40 seconds.

On an operating level (motor service S4), with a duty cycle of 95% and in starts per hour or equivalent thermal cycle: 3,5 In startup for 20 seconds

6. **Protections**

6.1 The starter will include the management of PTC probe.

6.2 The starter will calculate continuously the motor overheating from the real current value (the current must be measured and not estimated). Several classes of thermal protection will be proposed following the standard EN/IEC60947-4-2: Classes 10, 20, 30.The calculation of the thermal protection must be active even when the Soft-starter is not power energized.

6.3 The starter shall be protected against thermal overload.

6.4 The Soft-starter will detect an under- load from the motor current information. The detection threeshold and the allowed duration of the under- load shall be adjustable of 1 sec. That protection may result in a default on the Soft-starter or simply cause an indication in the form of an alarm on a output relay.

6.5 The Soft-starter will detect an over- load from the information of the motor current. The detection threshold and the allowed duration of the over-load shall be adjustable. The duration of overload may be adjustable from 0.1 seconds. That protection may result in a default on the starter or simply cause an indication in the form of alarm on a output relay.

6.6 The Soft-starter shall have protection against reverse-phase network, the loss of phase (s) on mains or on motor.

6.7 The Soft-starter will take into account the management of an external fault. When the contact is open, the Soft starter trips in fault.

6.8 The protections will always be maintained even the Soft-starter is by-passed internal or self.

7. **Communication**

7.1 The starter will include a multipoint serial link to be connected directly to a Modbus network.

7.2 The starter shall be able to be connected to Ethernet and other networks and communication bus option.

7.3 The communication shall provide access to the control, adjustment and monitoring of the Soft-starter.

8. **Main functions**

8.1 A second set of motor parameters can be switched by a logic input.

8.2 The Soft-starter will handle the by-pass itself: manage the closure of the by-pass at end of acceleration time and open that by-pass at end of stop sequence. That function must be compatible with the types of stop: freewheel, ramp. The soft starter to have an integrated Bypass contactor

8.3 The Soft-starter may control the line contactor. The contactor will be closed from a run control and open at end of shutdown of the motor.

8.4 The access to the settings can be locked by code. The monitoring parameters should remain accessible

9. **Monitoring**

9.1 The starter shall have a basic screen dialogue and programming push-buttons. An optional kit to get remote terminal will be offered.

9.2 The following information must be accessible on the screen dialog
- Motor current (by phase)
- Motor state
- Current status (acceleration, deceleration, ...).
- Operating time.
- The last fault occurred
- Fault history
- I/O status

9.3 The Soft-starter has in option advanced dialogue solutions such as:
software workshop for PC to prepare, store, download and print settings.
Terminal display with clear parameters.
For these tools, 6 languages are available: French, English, German, Italian, Spanish, and Chinese.

9.4 **Variable speed starter**

This section provides specification requirements for variable frequency drives herein referred to as AC Drives, for use with standard IEC or NEMA . Squirrel Cage Induction Motors for cooling tower. The AC Drive does not include motor in this specification.

To avoid any mismatch between the motor and its control equipment, the AC Drive shall be capable of auto adjustment by automatic measurement of the motor parameters without motor rotation.

9.4.1 **Submittals**

[6] submittal packages including drawings shall be furnished for Engineers approval prior to assembly of the AC Drives. These packages shall consist of elementary power and control wiring diagrams on one drawing and enclosure outline drawings. Standard catalog specification sheets showing voltage, horsepower and maximum current rating shall be furnished as part of the submittal package.

9.4.2 **Requirements for the Manufacturer**

Certifications
The Frequency Converter Manufacturer shall have a valid ISO 9001 (2000 version) certification and an applicable quality assurance system.

The Frequency Converter Manufacturer shall have the Environment Certification ISO 14001.
The Frequency Converter Manufacturer shall furnish the Product Environmental Profile (P.E.P.) on the engineer's request.

Experience
The Frequency Converter Manufacturer shall have adequate experience in frequency converter manufacturing and have adequate business volume in order to provide credibility in his commitments and a capability of long term support.

Local support

The Supplier shall have a permanent representative office with a trained and skilled support staff, in the country where the goods are delivered, in order to prove his commitment for local support and to provide a channel for communication. The local representatives shall be easily accessible and shall be able to arrive at the site within 24 to 48 hours' notice.

The engineers employed by the Supplier's regional office shall be certified by the Manufacturer and provide start-up service including physical inspection of the drive, connected wiring and final adjustments, to ensure that the AC Drive meets the required performance.

The Supplier shall be able to give basic drives training to the Customer's engineers, preferably on the site but anyway, in the country where the customer's site is. The training shall, as a minimum, include system concepts and basic troubleshooting. The Supplier shall also be capable of solving most AC Drive problems quickly..

The Manufacturer shall be able to offer commissioning of the drive to be done by the local office.

The most common spare parts like fuses, IGBTs as well as main control- and I/O-boards shall be available in 48 hours from the notification through a regional service center of the Supplier. The more rarely used spare parts should be available in maximum 5 days on site!

9.4.3 **Basic requirements for the AC Drives**

General requirements

- The AC Drive shall comply with National and International standards and the recommendations for electrical industrial control devices (IEC, EN, UL, NFC, VDE).
- ANSI/NFPA 70 : National Electrical Code
- EN50178 : Electronic equipment for use in power installation
- CSA C22.2 No. 14-M91 : Industrial Control Equipment
- IEC 68 Part 2-3 : Basis Environmental Testing Procedures Part 2: Tests – Test Ca: Damp Heat
- IEC 146.1 : Semiconductor Converters – General Requirements and Line Commutated Converters Part 1-1: Specifications of Basic Requirements
- IEC 664 : Insulation Co-ordination for Equipment Within Low-Voltage Systems
- IEC 447 : Man-Machine Interface Actuating Principles
- IEC 439 Part 1 :Low Voltage Switch gear and Control gear Components
- IEC 364 : Electrical Installation of Buildings

- IEC 204/NFPA 79 : Electrical Equipment of Industrial Machines/Industrial Machinery
- IEC 106 : Guide for Specifying Environmental Conditions for Equipment Performance Rating
- IEC 529 : Degrees of protection Provided by Enclosure
- IEC 1000 : Electromagnetic Compatibility
- IEC 1800 : Adjustable speed Electrical power drive systems
- IEC 721 : Classification of Environmental Conditions
- IEC 255-8 : Overload Relays
- IEC 801-2,-3,-4,-5 : Immunity Tests
- NEMA ICS Part 4 : Overload Relays
- NEMA ICS7 : Industrial Control and Systems Variable Speed Drives
- UL 508C : UL Standard for Safety Power Conversion Equipment

The AC Drive shall be of the most modern design, yet user friendly and be simple to install commission and maintain. The AC Drive shall be able to start and control the speed of a standard squirrel cage induction AC motor. The AC Drives shall be:

CE marked, conforming to European Low Voltage (73/23/CEE and 93/68/CEE) and EMC (89/336/CEE) Directives,

UL/CSA marked according to UL 508C.

The AC Drives have to be built to comply with the IEC standards. For the Australian market the AC Drive shall have a C-tick marking, for the Russian market or Eastern Europe market the AC Drive shall have a GOST marking.

The materials used in the AC Drive shall be recyclable, non-toxic and flame retardant. The AC Drive shall comply with the European directive RoHS (Restriction of Hazardous Substances) that prohibits the use of materials such as lead, chromium 6...

The AC Drive shall be a digitally controlled drive, using, at least, the Pulse Width Modulation (PWM) with flux vector control open loop and closed loop, with both speed and torque control modes, an algorithm to control unbalanced loads (ENA system), and a safety function (see chapter safety). It shall have IGBT's in the inverter section of the throughout the power range, and it shall have the following minimum specifications.

Operating conditions:

Rated Input Voltage	:	200V -15% 240V +10%, three-phase, or
Three phase	:	380V -15% 480V +10%,

Rated Input frequency	:	200V -15% 240V+10%, single-phase (ONLY up to 5.5kW, 7.5 HP)
Rated Input Frequency	:	50Hz –5% to 60Hz +5%
Fundamental Power Factor	:	0.97 or better at nominal load
Efficiency	:	≥ 98 % at nominal load
Output Voltage	:	0 - UN, three-phase
Output Frequency Range adjustable	:	0 to 1000 Hz up to 37kW (50HP),
	:	0 to 500 Hz above 37kW (50HP), Adjustable
Accel/Decel Time	:	0.01 – 6000 s, adjustable, linear, with S, with U or customised shapes

Overload capability (Constant Torque) :150% of nominal AC drive current for, and 165% of nominal AC Drive current for 2sec.

Operating ambient Temperature	:	-10°C up to 50 °C, for higher temperatures see below
Storage ambient Temperature	:	-25°C up to 70 °C
Maximum operating altitude	:	1000 m without derating 1000-3000 derating the current by 1% per additional 100 m. Limited to 2000 m for the “Corner Grounded” distribution network
Max. Relative Humidity	:	95 %, without condensation and dripping water. (IEC 60068-2-3)
Max. Corrosion Level of the Cooling Air	:	IEC 721-3-3, class 3C1. In option, conformal
Chemical Gases	:	coating shall be requested to comply with IEC 721-3-3 Class 3C2.
Solid Particles	:	IEC 721-3-3, class 3S2

Max. Vibration Level (IEC 60068-2-6)

2 to 13 Hz	:	1.5 mm, peak to peak
13 to 200 Hz	:	1 m/s2

Shock Level	:	according to IEC/EN 60068-2-27
Max. Ambient Pollution degree		
According to EN 50178	:	Degree 2, up to 15 kW (20 HP)
According to UL 508C	:	Degree 3, above 15 kW (20HP)
Main Protections	:	Overcurrent, short circuit between phase, short circuit between phase and ground, impedant short circuit, input phase loss, output phase loss, motor overload, overvoltage, undervoltage, overspeed, IGBT overtemperature, heatsink overtemperature, other internal faults.
Control supply	:	could be internal so provided by the AC Drive itself, or provided by an external 24V dc supply

The AC Drive shall be able to give a 100 % output current continuously in the above specified conditions. In order to ensure that the drive can provide the required output current in the specified ambient conditions, the Manufacturer shall inform the required derating, if the ambient temperature given in the project-specific specification is higher than 50 °C or if the installation altitude is more than 1000 m above the sea level. The derating factor shall be specified so that neither the lifetime of the AC Drive nor the unit's performance, overload capability included, nor the reliability of the AC Drive shall suffer.

9.4.4 AC Drive performance

Motor control type

- Sensoreless (SVC) voltage vector control for AC motors for multiple motors supply
- Sensoreless (SVC) current vector control for AC motors for a single motor supply
- Closed loop current vector control for AC motors for a single motor supply
- Volt per hertz 2 or 5 points for AC motors
- Sensoreless vector control for synchronous motors
- Energy Adaptation system (ENA) for unbalanced load

Speed range in the motor quadrant

- 1:100 in sensoreless vector control
- 1:1000 in closed loop vector control
- 1:50 in Sensoreless vector control for synchronous motors

Speed range in the generator quadrant

- 1:50 in sensoreless vector control
- 1:1000 in closed loop vector control
- 1:50 in Sensoreless vector control for synchronous motors

Overtorque capability

- at least 170% of the rated motor torque during 60s
- at least 200% of the rated motor torque during 2s

Speed accuracy

- ± 10% of the nominal slip of the motor in sensoreless vector control
- ± 0.01% of the nominal speed of the motor in closed loop vector control

Torque control accuracy

- ± 15% in sensoreless vector control for AC motors
- ± 5% in closed loop vector control for AC motors

Current at standstill

- 100% of the nominal peak current up to 75kW
- 80% of the nominal peak current above to 75kW

Braking capabilities

Up to 160kW, the drive shall integrate a braking IGBT

- 100% of the rated torque continously
- 170% of the of the rated motor torque during 60s

From 200 kW up to 500kW, the braking IGBT could be external

9.4.5 Quality assurance and warranty

Every AC Drive has to be tested functionally. The inverter part of the AC Drive or each inverter module at least has to be tested by running it with a motor at full nominal load. A test report of the tests made shall be delivered by the Frequency Converter Manufacturer on engineer's request.

An 18-month parts warranty shall be provided on materials and workmanship from the date of purchase.

9.4.6 Protections

1. Circuit breaker coordination and short circuit protection shall eliminate the need for current-limiting and semiconductor fuses. Tables for Type 2 coordination, combining circuit breaker, contactor and AC Drive shall be provided and certified.

2. The AC Drive shall be UL 508C listed for use on distribution systems. The AC Drive shall have a coordinated short circuit rating designed to UL 508C and NEMA ICS 7.1 and listed on the nameplate. The AC Drive shall not create a hazard in the event of a short circuit at any point within the AC Drive when it is

connected to a power source as specified on the nameplate and protected as specified.

3. Upon power-up the AC Drive shall automatically test for valid operation of memory, option module, loss of analog reference input, loss of communication, dynamic brake failure, DC to DC power supply, control power and the pre-charge circuit.

4. The Power Converter shall be protected against short circuits, between output phases and ground; supplies provided by the AC Drive shall be protected against short circuits and overloads.

5. The AC drive shall have a minimum AC undervoltage power loss ride-through of 200 msec. The AC Drive shall have the user-defined option of frequency fold-back to allow motor torque production to continue to increase the duration of the powerloss ride-through.

6. The AC drive shall have a selectable ride through function that will allow the logic to maintain control for a minimum of one second without faulting.

7. The deceleration mode of the AC drive shall be programmable for normal and fault conditions. The stop modes shall include freewheel stop, fast stop, DC injection braking and as fast as possible.

8. Upon loss of the analog process follower reference signal, the AC Drive shall fault and/or operate at a user-defined speed set by a software programmed speed settings or last speed.

9. The AC Drive shall integrate a protection against IGBT chips over temperature that is different from the heatsink overheat.

10. The AC drive shall have solid state thermal protection that is UL Listed and meets UL 508C as a Class 20 overload protection and meets IEC 947. The minimum adjustment range shall be from .25 to 1.36% of the current output of the AC Drive. The motor thermal state shall be memorized and shall decrease following the motor rating even when the power is OFF.

11. The AC Drive should be able to protect the motor when PTC probes are connected.

12. The AC drive should be able to limit the motor terminal voltage to twice the DC bus voltage.

13. The AC drive shall display all faults in plain text and help screens shall be available to guide the user in the troubleshooting. Codes are not acceptable.

9.4.7 Safety

1. The AC drive shall be integrated directly in the safety chain complying with EN 954-1 category 3, and with IEC/EN 61508-1 SIL2.

2. The AC drive shall integrate the “Power Removal” safety function which prohibits unintended equipment operation. The motor no longer produces torque.

3. This safety function shall comply with standard for safety of machinary EN 954-1, category 3; standard for functional safety IEC/EN 61508, SIL2 capability (safety control-signaling applied to processes and systems).

4. The “Power Removal” safety function shall have a redundant electronic architecture that shall be monitored continuously by a diagnostics function.

5. This SIL2 and category 3 level of safety function shall be certified as conforming to these standards by a certification body under a program of voluntary certification.

6. The Power removal function shall comply with the definition of the draft product standard IEC/EN 61800-5-2 for both stop functions, Safe Torque Off (“STO”) and Safe Stop 1 (“SS1”).

7. The AC drive manufacturer shall provide the certified schematics and the list of devices in order to comply with IEC/EN 60204-1 stopping category 0 and 1.

8. The relay contacts shall comply with EN-81 13.2.2.3

19. ELECTRIC MOTORS:

1. Electric motor shall be totally enclosed fan cooled type of protection IP55 and designed to work at 55^{o} C and 1000 meters above see level

2. All motor winding and slot insulation shall be non-hygroscopic of class B as minimum

3. All motor winding (Over 15HP) shall be provided with thermal winding temperature sensors embedded in the winder.

4. All motor shall be provided with terminal Block with cover from motor manufacturer Suitable for cable sized as indicated in the drawing.

5. All motors shall be listed by Under Writers Laboratories.

6. Kuwait Continuous rating of the motor shall not be more than 80% of British Standard rating or IEC rating.

9. SOFT STARTER (solid State) for Water Cooled Chiller (415 V)

The Chiller starter shall be free standing and intelligent type and shall be integrated to SCADA system as described in SECTION-43..

Solid-state with integral by pass contactor. The starter should be rated to operate at an ambient temperature of 55°C and shall be installed, wired and tested at the chiller manufacturer's factory prior to shipment. The starter shall be listed by Underwriters Laboratories and should be suitable to start chiller with the existing Diesel Generator (3 MVA).

Chiller starter panel shall include the following as minimum: -

9.1 Main Power Circuit breaker M.C.C.B.

9.2 Integral by-pass contactor

9.3 Micro-processor based over load protection similar to 239 Motor Protection Relay manufactured by General Electric or equal approved listed by Underwriter Laboratories.

9.3.1 3 phase over voltage protection.

9.3.2 3 phase under voltage protection.

9.3.3 Ground fault protection.

9.3.4 Phase loss / reversal / unbalance protection.

9.3.5 3 - phase digital ammeter and voltmeter.

9.3.6 Power factor digital meter.

9.3.7 Frequency digital meter / Watt Meter / Var Meter.

9.4 Pilot relays for control of chilled water pumps, cooling tower fan, shunt trip disconnect and remote alarm.

9.5 Branch Oil Pumps circuit breaker.

9.6 Surge protection capacitors.

9.7 Minimum Two KVA Control / Oil heater transformer in separate compartment.

9.8 Starter Management Module which communicates with the chiller control system to perform starting and stopping of the chiller, water pumps, and cooling tower fans as well as monitory starter operation and communication with B.A.S or HVAC Control Panel.

1.9 NEMA 1 enclosure with integral Fans for cooling with Thermostatic control and alarm / trip circuit if the fan not working or if the temperature inside starter is high.

1.10 The starter shall have terminal box for connecting incoming cable as shown on electrical drawing.

1.11 The operating principle of the starter will not have to rely simply on motor current limitation during the transitory phases or on a voltage ramp, but on motor torque control.

The starter will have to provide a torque ramp throughout the accelerating phase. Therefore, it will be able to control the torque throughout the entire starting phase and, if necessary, provide a constant motor torque throughout the accelerating phase

1.11 The soft starter shall comply the soft starter specification as per Item 7.13.

Attention:

A. Each Electrical components in the Chiller Station (i.e. Motor Protection Relay, Contactor, Measuring instrument, Solid state starter ... etc.) shall be UL approved listed and shall be size to operate at an ambient temperature 55°C and the Starter shall be installed, wired and tested at Chiller manufacturer's factory prior to shipment.

B. M.E.W has the right to deduct KD. 30,000/- for each starter not comply with the above specification or not supplied by the chiller manufacturer.

C. The specification for existing Diesel Generator is:

3.3 KV Emergency Diesel Generator.

Manufacture: TOYO – DENKISEIZUR		Serial No. 593036.
Model No. : 16 ZL – ST.		Eng. No. : 0002JZC
Cont. Rating: 4800 H.P.		Insulation Class : F
Volts – 3300	Cos Φ 0.8	FLD : Volt
KVA – 3150	Hz – 50	FLD : Amps.
Amps. – 551	R.P.M. – 750.	Amb. Temp. : 48.9^0 C.

D. All required works to start chiller complete with condenser water pumps and chilled water pumps and cooling tower with existing diesel generator shall be done by contractor including supply and installation of new diesel generator with higher capacity more than the existing diesel generator without any extra money and time.

E. MEW has the right to deduct KD. 120,000/- for each chiller with all accessories (i.e. condenser water pumps, Chilled water pumps, cooling tower) not operates with the existing 3.3 KVA Diesel Generator.

DISTRIBUTION BOARDS

20.1 **Description:**

A. Related Documents:

Drawings and general provisions of contract, including general and supplementary conditions apply to this section.

20.2 **Quality Assurance:**

A. Applicable Standards referred to in this Section:

IEC 60439-3	Distribution Boards
IEC 60947-2, IEC 60898	MCB's
IEC 60947-4	Contactors
IEC 364 and IEC 755	Earth Leakage Relays
IEC 60947-1 and 60947-4	Overload Relays
IEC 61008	RCCB
IEC 61009	RCBO

20.3 **Final Distribution Board (DB)**

20.3.1 Enclosures and installation systems

All final-distribution enclosures shall be selected from the same range, rated for an incoming current of up to 125A. Whatever the installation method (flush or surface mounted), they shall comply with International standard IEC 61439-3 / European standard EN 61439-3

> The degree of protection, as per IEC 60529, shall be at least , IP42 for enclosures with a door

> The low-voltage distribution board shall have a rated insulation voltage (Ui) of 500 V AC.

> The low-voltage distribution board shall have a rated operational voltage (Ue) of 415 V AC 50/60Hz.

> The low-voltage distribution board shall be capable of withstanding short-time withstand currents as below:

- Upto 125A Incomer : 15 kA rms for 0.25secs

> the Type tests shall be certified by an Independent Certification Body / Testing Laboratory (KEMA / DEKRA).

> the low-voltage distribution board shall accept a rated current up to 125A for distribution DIN isolator as incomer for Vertical and Split type DBs

> The complete busbar type distribution boards both vertical/split type must have been tested for 50 ambient temperature rise tests with natural ventilation.

> the metal enclosure of the distribution board shall be made of electro galvanised steel sheet metal thickness of 1.2mm and shall have received an anti-corrosion coating (hot polymerised polyester/epoxy powder)

Enclosures shall provide Class II total insulation (as per IEC / EN 61439-3, section 7.4.3.2) between outer space and all live components inside.

Outgoers will be identified by labels affixed on front of the switchboard, at least 5 cm high, aligned with each device,. Access to the inside of the enclosure for maintenance purposes shall be possible by removing the inner dead front / cover.

Common devices such as measurement and indication devices, pushbuttons, emergency off switches and socket-outlets may be installed together in an extension box which will form an integral part of the enclosure and easily accessible to users.

Cable entry to flush-mount and surface mount enclosures shall be possible for flexible conduits or insulated cables, from both top and bottom of the enclosure.

For cable running in the enclosure, adequate clearance shall be available on either side of the outgoing breakers (gutter space).

Enclosures shall be equipped with a removable chassis enabling cabling operations on a workbench, even if the back of the enclosure is already set on the wall. On the chassis, it shall be possible to adjust the height of the overall inner busbar assembly (pan assembly) over at least 2 cm. It shall also be possible to adjust the depth of the inner busbar assembly (pan assembly) to enable installation of non-modular devices, e.g. moulded-case incoming devices and achieve proper alignment of all outgoing circuit breakers with the inner cover / dead front.

In the busbar type DBs , the main copper bubar used in the pan assembly must be of high grade copper with tin plating and the busbar supports must be made of high

quality plastic material of ploy carbonate with 25% fibre content to provide very high strength to with stand higher lever of short circuit current withstand capabilities. The busbar support plastic materials must have been type tested as per IEC61439-2: resistance to corrosion (severity test A – indoor) : verification to resistance of insulating materials to normal heat (125 degrees) and also abnormal heat (960 degrees) and fire due to internal electric effects as per IEC60695-10-2 standard.

Inner busbar assembly (pan assembly) installation in the enclosure must be stable and functional even before it is permanently secured by screws.

Earth and earth/neutral terminal blocks in enclosures shall comply with standard IEC 61439-3. It shall be possible to install the earth and earth/neutral terminal blocks and distribution devices either at the top or bottom of enclosures, near the incoming cables.

Terminal blocks shall be designed to secure cables in compliance with standards IEC 60947-1, section 8.2.4, IEC 60998-1 and IEC 60998-2-1. For cable cross-sections up to 6 mm² (rigid or flexible without ferrules), cable connection shall not require tightening by the installer. Terminal-block extensions, e.g. for installation modifications, must be easy to add and dependable.

The connection between earth and neutral terminal blocks must be rigid and removable only using a tool.

It must be possible to install flush-mount enclosures without use of mortar. The front panels shall be perfectly seated, even if the rear part (flush-mount case) is imperfectly set or if the wall is irregular at the point of installation.

The colour of the enclosures shall be:

- RAL7032/RAL9002 mat finished grey / White

- It shall be possible for users to personalise doors without risk of touching live parts (non-transparent, transparent, images, wall paper, etc.).

20.3.2 Protective devices

Protective devices shall be of the modular type (DIN profile). To maintain the best cost/performance ratio between continuity of supply and safety, all devices shall be from the same range and the same manufacturer:

- Main incoming switches, incoming circuit breakers
- Surge arresters
- Residual current devices

- Miniature circuit breakerswith earth leakage protection

The following specifications shall be met by both residual-current circuit breakers and miniature circuit-breakers:

- The devices must be capable of heavy-duty operation and to that end, the manufacturer shall guarantee the following performance levels, defined by IEC / EN 60947-2 standards.

- Suitability for isolation (section 7.2.7)

- Rated insulation voltage (section 4.3.1.2): 500 V

- Pollution degree (Part 1, section 6.1.3.2): 3

- rated impulse-withstand voltage (section 4.3.1.3): 6 kV

To ensure the longest possible service life, switching mechanisms shall be designed to make the contact-closing speed totally independent of the operator's action.

Contact positions shall be clearly indicated on the front of devices and marked:

- "I - ON", standing for device contacts closed, circuit energised,

- "O - OFF" with a green background, standing for device contacts open, circuit disconnected.

For safety of non-skilled users, accessible parts of the devices, when in a suitable enclosure, shall feature:

- **degree of protection IP40 (as per IEC 60529)**
- **Insulation class II. (as per IEC 60364).**

The protective devices shall all provide a differentiated indication, enabling to identify the reason for an **OFF POSITION: MANUAL OPERATION OR FAULT-DRIVEN TRIP.**

20. SURGE ARRESTERS

Protection of loads against destruction by lightning shall be implemented in final distribution switchboards: each load shall be protected by a surge arrester located at an electrical distance not exceeding 30 meters.

Therefore, final distribution switchboard shall embed a surge arrester compliant with IEC 61643-1 / EN 61643-11 standard. Compliance shall be proved by NF quality label printed on the device.

The surge arrester, type 2 according to IEC 61643-1 / EN 61643-11 will limit voltage to never exceed:

- 1,4 kV live to earth
- 1,0 kV phase to neutral.
  Its operating voltage Uc will not be lesser than 340 V between live and earth as well as phase to neutral.

It will be made of withdrawable cartridges, with rated maximum discharge capacity 8 kA.

The surge arrester will be set so as to ensure the distance between its earth terminal and the incoming earth terminal block not to be more than 15 cm.

Surge protection out of order (missing cartridge, replacement required) will be:

- Notified by an indicator on front
- Reported to ….. by means of an indication switch.

According to 61643-1 / EN 61643-11, the surge arrester shall be associated with a dedicated disconnector, the opening of which will not disturb or turn off power supply to any downstream located load. This disconnector will be made of a circuit-breaker, compliant with IEC / EN 60 898 standard.

Coordination between circuit-breaker and surge arrester, according to § 6.2.7. Of above standard, will be certified by the manufacturer.

Disconnecting circuit-breaker shall be integrated with the surge arrester: in case of trip, it will be possible to reset it only once all required cartridges have been replaced.

21. RESIDUAL CURRENT CIRCUIT-BREAKERS

RCCBs shall comply with international standard IEC 61008 / European standard EN 61008.

Compliance with the standard shall be certified by the VDE organisation and its quality mark shall be visible on the devices.

For each device, the characteristics shall be indicated on the single-line diagram as per standard IEC / EN 61008:

- Number of poles (section 4.3),
- rated current (section 5.2.2),
- Rated residual operating current (section 5.2.3).

The rated making and breaking capacities (sections 5.2.6 and 5.2.7) shall be at least equal to 1.5 kA both for fault currents between live conductors (Im) and for earth-fault currents (I□m).

The rated conditional short-circuit currents (Inc et I□c, sections 5.4.2 and 5.4.3) shall be greater than or equal to the prospective short-circuit current at the point of installation (Isc as per IEC 60364). The manufacturer shall guarantee these values do not differ from the rated breaking capacity of the circuit breaker providing short-circuit protection of the RCCB.

RCCBs located upstream of the following loads shall have a reinforced level of performance to restrict power outages to the strict minimum required for user safety:

- Sets of fluorescent lighting, halogen lighting supplied with LV or ELVpower,
- Groups of PCs and work stations,
- Motors driven by single-phase variable-speed drives, etc.

The reinforcement in performance means that the RCCB shall not trip in the following situations:

- Continuous 1 kHz leakage current, 8 times higher than the rated tripping threshold (as per IEC 60479-1),
- Leakage currents and transient overvoltages due to lightning strikes, switching, decoupling capacitance discharges, etc.:
  - 5 kV peak voltage for a 1.2/50 □s wave (IEC/EN 61000-4-5),

- 5 kÂ leakage current for an 8/20 □s wave (IEC/EN 61008),
- 400 Â leakage current for a damped sinusoidal 0.5 □s / 100 kHz ring wave (IEC/EN 61008),
- residual current equal to 5 times the rated residual operating current for a duration less than or equal to 10 ms,
- Very high-frequency inducted or conducted disturbances (starting at 150 kHz).

The RCCBs must trip for fault currents with a DC component (type A as per IEC 60755).

The same is required of residual current devices located downstream of UPSs.

RCCBs protecting three-phase variable-speed drives shall be type B as per IEC 60755.

22. CIRCUIT BREAKERS INTEGRATED WITH EARTH LEAKAGE PROTECTION-PROTECTING FINAL-DISTRIBUTION CIRCUITS

Circuit breakers shall comply with international standards IEC 60898 and IEC 60947-2 / European standard EN 60898 and EN 60947-2. Compliance with these standards shall be certified by the VDE organisation and its quality mark shall be visible on the devices.

For each device, the characteristics shall be indicated on the single-line diagram as per standard (IEC / EN) 60898:

- Number of poles (section 4.1),
- rated current (section 5.2.2),
- breaking capacity (section 5.2.4),
- Type according to the instantaneous tripping classification (section 4.5).

The specified values of breaking capacity shall be also be valid in case of short circuit between phase and protective earth (Icn1)

If not specified on the diagram, the breaking capacity shall be 10000A minimum.

Circuit-breakers shall be capable of operation under ambient temperature up to 50 °C, without derating of their overload tripping threshold with respect to their rated operating current.

Circuit breakers rated up to 32 A shall be the current-limiting type (category 3 as per EN 60898 appendix ZA). For circuit breakers rated 16 Amps, the thermal stress during a short-circuit, dissipated in the concerned circuits shall not exceed:

- 25000 A^2s for a prospective short-circuit current of 10 kA rms (400 V three-phases).

Where the line supplying the switchboard is protected by a circuit breaker rated 125 Amps or more, the protection provided by this one shall be totally selective with respect to circuit breakers located in the switchboard (up to 63 A, type B or C).

In compliance with international standard IEC 60364 / European standard EN 60364 section 411.3.3, sub distribution circuit breakers protecting general-usage socket-outlets with rated current not exceeding 20 A should provide additional protection against direct contacts.

These devices shall comply with international standard IEC 61009 / European standard EN 61009 and shall have a rated residual operating current of 30 mA.

6. Communication with BMS

Specification for a communicating power monitoring control and metering system for LV electrical installation

1. General recommendations:

Communicating low voltage switchboards are a response to regulatory incentives and the need to control power consumption and energy costs

They also improve continuity of service by increasing the availability of power.

The installation switchboard shall therefore be equipped with a communicating system that makes it possible to:

- monitor modular protection and control units and provide the centralised management system (PLC, supervisor, management software, etc.) with information on their status.
- transmit orders from the centralised system to the switchboard control units
- meter and transmit installation power consumption data to the centralised system

2. Applicable standards:

Number	Title	Use
IEC/EN – 61131-2	Programmable controllers - Equipment requirements and tests	Define Input and Output signal characteristics
IEC/EN – 60947-5-1 Part 5-1	Control circuit devices and switching elements – Electromechanical control circuit devices	Performance and tests of auxiliary contacts
IEC 60947-5-4	Control circuit devices and switching elements –Method of assessing the performance of low-energy contacts	Performances of low energy auxiliary contacts
IEC/EN 61439-1 & 2	Low-voltage switchgear and controlgear assemblies	Performance of the electrical assembly
IEC/EN – 60664-1	Insulation coordination	Characteristics of devices for insulation
IEC/EN – 62053-21 & 31	Meter standard	Pulse metering

3. Characteristics, operating principle and indications:

3.1 General characteristics

The LV distribution communication system comprises:

- One or more communicating data concentrators
    - using an open protocol such as Modbus, for example
    - whose inputs / outputs are organised by channel, with each channel used to connect one electrical device
    - compliant with the IEC/EN – 61131-2 standard
    - supplied by safety extra low voltage <= 24 V DC
- Indication auxiliaries that signal modular circuit breaker open/closed and tripped status
    - compliant with the IEC/EN 60947-5-4 standard
    - output voltage 24 V DC
- Auxiliaries for control and indication of open/closed status of control units (contactors and impulse relays) in accordance with the IEC/EN 60947-5-1 standard
    - Output voltages 24 V DC and 230 V AC
- Connection cables between the data concentrator and the auxiliaries equipped with **plug-in** connectors.

  The system shall allow the connection of monitoring and control units equipped with 24 V DC contacts.

3.2 Operating and installation principles

3.2.1 – Positioning, installation and connection of communicating data concentrators

- The data concentrators shall be positioned for quick viewing of connections with the monitoring and control devices
- The data concentrators shall be interconnected by Modbus chaining
- They shall be capable of being installed between the rows of modular devices, without taking up any additional space on the DIN rails
- The data concentrators shall be equipped with plug-in type input/output terminal blocks
- The concentrators / devices links shall preferably be of the prefabricated type with connectors that allow the concentrator to be connected to the devices in a single operation and with no risk of error
- The data concentrators may be mounted on the power distribution blocks so as to optimise the combined installation of power distribution and monitoring.

3.2.2 – Operation of the communicating system

- The data concentrators shall be capable of being easily integrated into the installation's communication network thanks to automatic adaptation of their communication parameters to match those of the network
- They shall provide data to the supervisor in Modbus tables, at fixed addresses that require no configuration
- The data shall be of the following type:
    - position of inputs/outputs or
    - calculated values: number of switching operations of downstream devices, load operating time, pulse metering with conversion to significant values
- The concentrators shall be capable of receiving from the supervisor, by writing in the Modbus table at fixed addresses requiring no configuration, "open / close" type orders (0 or 1) applicable on each channel
- They shall be capable of having the orders executed by the control devices, after having taken into account the devices' real positions
- The auxiliaries for control and indication of the open/closed status of control units (contactors and impulse relays) shall be capable of processing both 24 V DC and 230 V AC controls and of managing priorities between 24 V DC and 230 V AC.

3.2.3 – Testing of the system in the switchboard

The manufacturer shall supply a (software) tool for overall testing of the system, within the limits of the switchboard: the entire data transmission and control chain between the modular devices and all of the concentrators, including communication.

The test tool shall supply a report that includes the list of all the devices connected to each channel of the data concentrators as well as a diagram describing the configuration of the system with indication of the associated Modbus addresses.

4. 4. <u>Operation and maintenance</u>

- The communicating data concentrators shall store all of the calculated values, including in the event of a 24 V DC power failure.
- They shall be replaceable without requiring any reconfiguration other than that related to the meters
- The system shall be capable of taking into account new modular devices added to the installation without requiring any reconfiguration of the data concentrator.

23. FIRE ALARM SYSTEM

24.1 General:

The specifications mentioned below are the minimum and guidelines to the contractor. However, the contractor should provide the latest configuration including the hardware and software available from the manufacturer at the time of approval such as advanced model, type, accuracy, … etc.

24.2 Description of Work

A. The contractor shall design, supply, material, installation, and commissioning of the microprocessor controlled, intelligent (addressable) fire detection, alarm system required to form a complete coordinated system ready for operation as per latest regulation of Kuwait Fire Department.

B. A new intelligent (addressable) microprocessor controlled fire detection, alarm and voice evacuation system shall be installed in accordance with the specifications and drawings. It shall include, but not be limited to, addressable initiating devices, alarm notification appliances, fire telephones, fire alarm control panel, power supplies, battery, auxiliary control devices, annunciators, and wiring as shown on the drawings and specified herein.

C. The system shall comply with requirements of NFPA 72 for protected premises signaling systems and requirements of Kuwait Fire Department (KFD). The system shall be electrically supervised and monitor the integrity of all conductors.

D. All materials and shop drawings shall be approved by Kuwait Fire Department before execution of the work.

E. Coordinate with fire fighting system, HVAC system, elevators, smoke ventilation system, fire doors, BAS, security management system etc. and provide necessary interfaces as specified elsewhere in the relevant specifications in order to facilitate an automated and integrated fire & life safety system.

Abbreviations

CACF - Central Alarm and Control Facility

FACP – Fire Alarm Control Panel

DGP - Data Gathering Panel (FACP)

SLC - Serial Loop Communication

SCP - Satellite Control Panel

EVAC - Emergency Voice and Communication

CPU - Central Processing Unit

LED - Light Emitting Diode

LCD - Liquid Crystal Display

GUI - Graphical User Interface

RAU - Remote Audio Unit

APS - Auxiliary Power Supply

AFF - Above Finished Floor

AHJ - Authority Having Jurisdiction

KFSD – Kuwait Fire Service Directorate

NFPA – National Fire Protection Association, USA

BS EN – British European Standard

MEW – Ministry of Electricity & Water, Kuwait

24.3 Quality assurance

General

i. The fire detection, alarm and voice evacuation system shall be intelligent addressable and microprocessor based type to achieve early detection and warning in case of a fire incident.

ii. All components of the fire alarm system shall be from a single source who assumes responsibility for compatibility of system components.

iii. Comply with local building codes, MEW and KFD standards

iv. Fire detection and alarm system shall be user friendly and easy to operate and maintain. Proprietary methods, which will make the end user dependent on the system supplier for maintenance, are not acceptable.

A. Manufacturer's Qualifications

i. Manufacturer shall be an approved company by KFD.

ii. Manufacturer shall have minimum 10 years experience in design, engineering, manufacture and service of fire detection and alarm system equipment.

iii. Manufacturer shall be approved to ISO 9001:2008 quality system standard for design, engineering, manufacture and service of fire detection and alarm system equipment.

Contractor's Qualifications

iv. Fire detection and alarm system contractor shall be Grade 1 approved by KFD

v. The contractor shall have a minimum of 10 years experience in design, installation, commissioning and maintenance of fire detection and alarm systems, at least 5 years of which must be with digital addressable systems.

vi. The contractor shall have an adequate number of competent staff trained and experienced in the design, installation, commissioning and maintenance of analogue addressable fire detection and alarm systems.

B. Local Supplier's Qualifications

i. The local supplier shall be a Kuwaiti company having Ministry of Commerce approved agency agreement with the manufacturer and approved by KFD for distribution and service of Manufacturer's products in Kuwait.

ii. The local supplier shall have competent staff trained and certified by the manufacturer for installation, programming, commissioning and maintenance of Manufacturer's products.

iii. The local supplier shall keep sufficient stock of spare parts and shall be able to provide maintenance services for operation and maintenance of the system in case if required by the client.

iv. The local supplier shall guarantee the availability of spare parts and technical support for the supplied fire detection and alarm system for a minimum period of 10 years.

C. Applicable codes and Standards

The specifications and standards listed below form a part of this specification. The system shall fully comply with these standards.

NFPA 70 - National Electrical Code (NEC)

NFPA 72 - National Fire Alarm Code

NFPA 101 - Life Safety Code

UL268 / BS EN54-7 - Smoke detectors for fire protective signaling systems

UL864 / BS EN54-2 - Control units for fire protective signaling systems

UL864 / BS EN54-18 – Input / Output devices

UL864 / BS EN54-17 – Short circuit isolators

UL268A / BS EN54-27 - Smoke detectors for duct applications

UL521 / BS EN54-5 - Heat detectors for fire protective signaling systems

UL464 / BS EN54-3 - Audible signaling appliances

UL38 / BS EN54-11 - Manual call points

UL 346 / EN 12259-5:2002 – Water flow indicators for fire protective signaling systems

UL1638 / BS EN54-23: Visual signaling appliances

UL268 / BS EN54-12 – Beam smoke detectors

UL1481 / BS EN54-4 – Power supplies for protective signaling systems

UL1480 / BS EN54-24 – Speakers for protective signaling systems

UL1711 / BS EN54-16 – Amplifiers for protective signaling systems

Local and State Building Codes

All requirements of the Authority Having Jurisdiction (AHJ)

Kuwait Fire Service Directorate regulation

D. Product Approvals

The system shall have proper listing and/or approval from either of the following internationally recognized agencies:-

UL Underwriters Laboratories Inc., USA

FM Factory Mutual Systems, USA

ULC Underwriters Laboratories of Canada

LPCB Loss Prevention Certification Board, UK

17.4 Submittals

Submit the following according to Conditions of Contract and Specifications for Approval from the Engineer and KFD

A. Product Data

i. Schedule of Materials: Including details of all system components such as description, model/part numbers, quantity, manufacturer information, KFD & international approvals/listing etc.

ii. Product data sheets: For each system component, highlighted to indicate the selected models, product specifications or functions required to meet this specification.

B. Shop Drawings

i. System layout plans: Layout plans shall be prepared in suitable scale (1:50, 1:100 or 1:200) to indicate location of Fire Alarm Control Panel (FACP), annunciators, detectors, call points, alarm notification devices, auxiliary control devices. Layout plans shall be with dimensions of spacing and area coverage of detectors, manual call points and alarm notification devices. System layout plans shall also show the wiring details, raceway/conduit details, routing, fire zone information etc.

ii. Schematic riser diagrams: Provide complete riser diagrams indicating the wiring sequence of devices and their connections to the control equipment. Riser diagrams shall provide overview of the overall system configuration, loop details, device addresses, circuit identification etc. Provide a complete description of the system operation in matrix format on the riser drawing

iii. Installation Details: Installation details of system components as per manufacturer's recommendation, elevations, sections to indicate device locations, installation heights etc.

iv. Provide point-to-point wiring diagrams showing the points of connection and terminals used for electrical field connections in the system, including interconnections between the equipment or systems that are supervised or controlled by the system. Diagrams shall show connections from field devices to the FACP and remote fire alarm control units, initiating circuits, switches, relays and terminals

C. Design Data

i. System power calculations to make sure that the 24 VDC power supply units are capable of supplying required power for all input and out devices. 20% spare capacity shall be considered

ii. Back up battery calculations to make sure that selected battery size is suitable to keep the system operational for the prescribed time periods in case of primary mains power failure. 20% spare capacity shall be considered

iii. Voltage drop calculations to indicate that sufficient voltage is available for proper operation of the system and all components, at the minimum rated voltage of the system operating on batteries

iv. System operation description including method of operation and supervision of each type of circuit and sequence of operations for all manually and

automatically initiated system inputs and outputs. A list of all input and output points in the system shall be provided with a label indicating location or use of IDC, NAC, relay, [Sensor,] and auxiliary control circuits

v. Details of design criteria such as basis of selection of type of fire detectors and notification appliances in typical areas protected by the system, detector area coverage, audible and visual alarm coverage, sound pressure level attenuation and calculations to show that minimum sound levels available in critical areas.

D. Submittal to KFSD

Submit the following documents as specified in the preceding sections to KFD and obtain approval before commencing the works

i. Product data including schedule of materials and data sheets

ii. System layout plans

iii. Installation Details

iv. Schematic riser diagrams

E. Operation and Maintenance Data

i. Operating instructions for FACP

ii. Final as built revision of all shop drawings

iii. System operation and maintenance data for inclusion in Project Operating and Maintenance Manual. Include data for each type product, including all features and operating sequences, both automatic and manual. Provide the names, addresses, and telephone numbers of service organizations

iv. System operation description covering this specific Project, including method of operation and supervision of each type of circuit and sequence of operations for all manually and automatically initiated system inputs and outputs. Manufacturer's standard descriptions for generic systems are unacceptable.Product certification signed by the manufacturer of the fire alarm system components certifying that their products comply with indicated requirements

v. Record of system field tests

vi. Original and backup copies of all software delivered for this project shall be provided, on each type of CD/DVD media utilized

vii. Spare parts list which shall be with manufacturer’s part numbers. The list shall include all modules and components of the fire alarm panel, field devices.

24.5 Delivery, Storgae and handling

Deliver, store, protect and handle products to site under provisions of contract specifications. Accept material on site in original packing and inspect for damage. Protect from moisture by using appropriate coverings and store in dry interior locations.

24.6 Guarantee and Maintenance Service

24.6.1 All work performed and all material and equipment furnished under this contract shall be free from defects and shall remain so for a period of at least Two (2) years from the date of acceptance. The full cost of maintenance, labor and materials required to correct any defect during this one-year period shall be included in the submittal bid.

24.6.2 Repair services and replacement parts for the system shall be available for a period of 10 years after the date of final acceptance. During guarantee period, the service technician shall be on-site within 24 hours after notification. All repairs shall be completed within 24 hours of arrival on-site.

24.6.3 The inspection, testing and maintenance of fire alarm systems, initiating devices and notification appliances shall comply with the requirements of NFPA 72, 2010 edition, Chapter 14 and requirements and standards of KFD.

24.7 Training:

Equipment manufacturer or trained instructor from local supplier shall provide 3 days on site technical training to end user's maintenance staff (10 engineers + 10 technicians). Training shall allow for classroom instruction as well as individual hands on programming, troubleshooting and diagnostics exercises.

24. ELECTRIC TRACTION ELEVATORS

A. General

This specification covers the functional and technical requirements for supplying and installing testing and commissioning all Elevators complete in accordance with the requirements of the contract documents.

B. Include for the following works mentioned below in association with the installation of the elevators. Comply with civil and structural work requirements as per fire protection systems by Kuwait fire brigade as applicable.

All the following shall be done by the contractor: -

1. Structure to carry all structural reactions, impact and uplift loads imposed by the elevator equipment and its guide rails, beams, etc.

2. Barricades to protect the hoist way openings during the period of installation of elevator equipment.

3. Protection of hoist way entrance head and side jamb, with plywood after installation while construction work is in progress.

4. Water proofing of elevator pits, as necessary, after setting of all pit supporting steel and rail inserts.

5. Access doors, railings, pit ladders, support for elevator buffers.

6. Electrical works for the installation of electrical power supplies, lighting, socket outlets smoke detectors and telephone outlets with supply power feeders and final connection from power point to equipment.

7. Permanent lighting fittings with switches and grounded receptacles in each elevator pit.

8. Electric power of permanent characteristics for installing, testing and adjusting the elevator equipment.

9. The elevator shall have credits to use in green building.

10. Volt free contacts in as required for the fire operation from fire alarm panel and interfacing with fire alarm system and Load Management System.

11. Hoist way lighting as required.

12. Ring earth system of elevator equipment.

25.1 <u>Work Required</u>:

1. The work required under this section consists of all labor, materials and services required for the complete installation (including operational verification) of all the equipment required for the elevator(s) as herein specified.

2. All work shall be performed in a first class, safe and workmanlike manner.

3. In all cases where a device or part of the equipment is herein referred to in the singular, it is intended that such reference shall apply to as many of such devices or parts as are required to make complete installation.

4. Applicable Codes: Comply with applicable building codes and elevator codes at the project site, including but not limited to the following:

   i) EN81 Codes for Elevators
   ii) Kuwait KFD Regulations for Passenger & Goods Lifts

25.2 System Description

A. Equipment Description: Machine roomless gearless traction elevator

B. Equipment Control: VVVF Control System.

C. Quantity of Elevators as minimum in the Bill of Quantity for each site.

D. Main Power Supply: 415, Volts + or - 5% of normal, three-Phase, with a separate equipment grounding conductor.

E. Car Lighting Power Supply: 240 Volts, Single-phase.

F. Machine Location: **Machine Room-Less** inside the hoistway at the top or machine room above hoistway.

G. Signal Fixtures: Manufacturer's standard.

H. Controller Location: Controller(s) shall be located adjacent to the hoistway at the top landing. The exact location shall be determined at site after full coordination with other services.

I. Performance:

1. Car Speed: $\pm$ 5 % of contract speed under any loading condition or direction of travel.
2. Car Capacity: Safely lower, stop and hold up to 125% of rated load.

J. Ride Quality:

1. Vertical Vibration (maximum): 20 - 25cm/s²
2. Horizontal Vibration (maximum): 8 - 10 cm/s²
3. Vertical Jerk (maximum): 1.2 - 1.4 m/ sec^3)
4. Acceleration/Deceleration (maximum): 0.5 - 0.7m/ sec^2
5. In Car Noise: 50 - 54 dB(A)
6. Stopping Accuracy: $\pm$ 3 mm)

K. Operation:
Simplex Collective Operation: Using a microprocessor-based controller, operation shall be automatic by means of the car and hall buttons. If all calls in the system have been answered, the car shall park at the last landing served.

L. Operating Features

1. Full Collective Operation
2. Anti-nuisance.
3. Fan and Light Protection.

4. Load Weighing Bypass.
5. Independent Service.
6. Firefighters Operation-Phase 1 & Phase 2 (For a common elevator in a group)
7. Top of Car Inspection.
8. Relative System Response Dispatching.
9. MRO Manual Rescue Operation

M. **Door Control**:

1. Door control to open doors automatically when car arrives at a landing in response to a normal hall or car call.

2. Elevator doors shall be provided with a reopening device that will stop and reopen the car door(s) and hoistway door(s) automatically should the door(s) become obstructed by an object or person.

   Primary door protection shall consist of a two dimensional, multi-beam array projecting across the car door opening. Under normal operation and for any door position, the system shall detect as a blockage an opaque object that is equal to or greater than 33 mm in diameter when inserted between the car doors at vertical positions from within 25 mm above the sill to 1800 mm above the sill.
   The reaction time of the door detector sub-system shall not exceed 60.

3. Door nudging operation to occur if doors are prevented from closing for an adjustable period of time.

25.3 Submittals

A. Product Data: Submit manufacturer's product data/catalogues for each system proposed for use. Include the following:

1. Signal and operating fixtures, operating panels and indicators.
2. Cab design, dimensions and layout.
3. Hoistway-door and frame details.
4. Electrical characteristics and connection requirements.
5. Expected heat dissipation of elevator equipment in control room space

B. Shop Drawings: Submit approval layout drawings include the following:

1. Car, guide rails, buffers and other components in hoistway.
2. Maximum rail bracket spacing.

3. Maximum loads imposed on guide rails requiring load transfer to building structure.
4. Clearances and travel of car.
5. Clear inside hoistway and pit dimensions.
6. Location and sizes of access doors, hoistway entrances and frames.
7. Emergency landing device.

C. Operations and Maintenance Manuals: Provide manufacturer's standard operations and maintenance manual.

25.4 Quality Assurance

A. Manufacturer: Elevator manufacturer shall be ISO 9001 certified, The lift equipment is in full conformity with the European Standards EN-81-Part 1 1998 "Safety Rules for the construction and installation of Electrical Lifts" / EN-81-Part 2 "Safety Rules for the construction and installation of lifts".

B. Installer: Elevators shall be installed by the manufacturer.

C Inspection:

1) Elevator Contractor shall arrange factory visit for 3 MEW Engineers (2 from Technical Services Department and 1 from Water Department) to inspect and witness performance of representative Elevator and the equipment at the factory. All necessary cost for accommodation at least for one week, transportation, and air ticket should borne by the contractor.

2) Permits, Inspections and Certificates: The Elevator Contractor shall carry out field testing through the KFD and approved Third Party Inspection Authority like Lloyd's Register, Bureau VERITAS or equal approved at the time of handing over and every year till the end of the contract. The payment for all expenses related to testing and approval shall be at cost of the contractor.

D. Approval by Public Authorities

Ensure that, where applicable, the work and any materials used in the execution of the work in accordance with the contract, comply with the requirements of KFD and Kuwait Municipality and MEW specification.

PRODUCTS

25.5 Design & Specifications

A. Provide gearless traction passenger elevators. The control system and car design based on materials and systems manufactured by Approved Manufacturer. Specifically, the system shall consist of the following components:

1. An AC gearless machine using embedded permanent magnets mounted (**Machine Room or machine room less)** at the top of the hoistway.

2. Polyurethane Coated Steel Belts (CSB's) or equal approved for elevator hoisting purposes.

B. The controller shall provide protection against the following:

1. Phase reversal of the power supply.
2. Overload
3. Single phasing
4. Under voltage, under frequency
5. Earth leakage, earth fault
6. Short circuit

C. **Emergency Landing Device**

Upon power failure, a car equipped with this function automatically moves and stops at the nearest floor using a rechargeable battery, and the doors open to facilitate the safe evacuation of passengers.

25.6 Approved Manufacturers

A- Manufacturers and installers must demonstrate a record of at least fifteen (15) years of successful supply and installation of their products in Kuwait with ISO certificate.

B- Manufacturers and Systems: Subject to compliance with requirements, provide products by one of the following and as per specified sourcing only:

1. KONE Inc. (Finland)
2. Otis Elevator Co. (France.)
3. Schindler Elevator Corp. (Europe.)
4. Thyssenkrupp (Europe)
5. Mitsubishi (Japan.)
6. Hitachi (Japan)

7. Or Equal approved manufacturers in USA, Japan, Korea and Europe and shall have 10 years' experience in Kuwait with LEED credits by using more energy coefficient and environmentally friendly elevators and also shall be approved by Kuwait Fire Brigade as class A certified company.

C- All must have approved with LEED credits to use in Green building.

25.7 Equipment: Control Room Components

A. Controller: A microcomputer based control system shall be provided to perform all of the functions of safe elevator operation. The system shall also perform car and group operational control.

1. All high voltage (110V or above) contact points inside the controller cabinet shall be protected from accidental contact in a situation where the controller doors are open.

2. Controller shall be separated into two distinct halves; Motor Drive side and Control side. High voltage motor power conductors shall be routed so as to be physically segregated from the rest of the controller.

B. Drive: A Variable Voltage Variable Frequency AC drive system shall be provided.

25.8 Equipment: Machine and Governor

A. Machine: AC gearless machine, with a synchronous permanent-magnet motor, dual solenoid service and emergency disc brakes, mounted at the top of the hoistway.

B. Elevator starts per Hour -180

C. Governor: The governor shall be a tension type governor.

D. Buffers, Car and Counterweight:
Type: Buffer polyurethane or manufacturer's standard

They are located under the bottom part of the car / counterweight

E. Counter weight: Bolted frame counter weight without safety, Fillers of concrete or cast iron. (Safety is required if accessible space is available under the elevator pit)

F. Hoistway Operating Devices:
1. Emergency stop switch in the pit
2. Terminal stopping switches.

G. Positioning System: Consists of an encoder, reader box, and door zone vanes.

H. Guide Rails and Attachments: Guide rails shall be Tee-section steel rails with brackets and fasteners. Side counterweight arrangements shall have a dual-purpose bracket that combines both counterweight guide rails, and one of the car guide rails to building fastening.

I. Coated Steel Belts: Polyurethane coated belts with high-tensile-grade, zinc-plated steel cords.

J. Governor Rope: Governor rope shall be steel and shall consist of at least eight strands wound about a sisal core center.

K. Fascia: Galvanized sheet steel shall be provided at the front of the hoistway.

L. Hoistway Entrances:

1. Frames: Entrance frames shall be of bolted construction for complete one-piece unit assembly. All frames shall be securely fastened to fixing angles mounted in the hoistway.
2. Sills shall be Aluminum
3. Doors: Entrance doors shall be of hollow metal construction with vertical internal channel reinforcements.
4. Fire Rating: Entrance and doors shall be fire rated for 2 hours as per EN-81 codes of regulation
5. Entrance Finish: Stainless steel Hairline finish

M. Counterweight Safeties: To be provided if accessible area is provided under the pit.

25.9 Equipment: Car Components

A. **Carframe and Safety:** A carframe fabricated from formed or structural steel members shall be provided with adequate bracing to support the platform and car enclosures. The car safety shall be flexible guide clamp type.

B. Steel Cab
Brushed stainless steel

C. Car Front Finish: Bushed stainless steel

D. Car Door Finish: Brushed stainless steel

E. Ceiling Type: Curved ceiling in Stainless steel finish with spot lights.

F. Emergency Car Lighting: An emergency power unit employing a 6-volt sealed rechargeable battery and totally static circuits shall be provided to illuminate the

elevator car and provide current to the alarm bell in the event of building power failure.

Fan: Fan shall be provided in the car ceiling. A switch shall be provided in the car-operating panel to control the fan.

G. Handrail: Handrails shall be provided on the side walls**,** rear walls of the car enclosure as per manufacturer design catalogues.

H. Car & Landing Sills: Aluminum

I. Emergency Exit Contact: An electrical contact shall be provided on the car-top exit. Only for car more than 8 passenger capacity.

J. Car guiding device: Sliding shoes with polyamide gibes or equal approved.

K. Car Lighting: Sufficient car lighting using LED lights that last up to 10 times longer than conventional fluorescent lamps shall be provided, Minimum of 50Lux as per EN81 codes.

25.10 Equipment: Signal Devices and Fixtures:

A. **Car Operating Panel:** A car operating panel shall be provided which contains all push buttons, key switches, and message indicators for elevator operation. The car operating panel shall have a Brushed stainless steel finish.

1. Applied car operating panel shall be curved type in stainless steel brushed finish. It shall contain a bank of round metal mechanical illuminated buttons. Flush mounted to the panel and marked to correspond to the landings served, an emergency call button, door open and door close buttons, and switches for lights, inspection and the exhaust fan. The emergency call button shall be connected to a bell that serves as an emergency signal. All buttons to have raised numerals and Braille markings. Red LED halo illumination with brushed stainless steel.

   The car operating panel shall be equipped with the following features:

   Standard:

   i. Raised markings and Braille shall be provided to the left hand side of each push-button.
   ii. Car Position Indicator at the top of and integral to the car operating panel.
   iii. Door open and door close buttons.
   iv. Automatic light and fan operation.
   v. Inspection key-switch.
   vi. Elevator Data Plate marked with elevator capacity and car number.

vii. Illuminated alarm button with raised markings.

2. Car Position Indicator: Liquid Crystal Display

Marking white back lighted on blue screen

i. 1 logo for Car Direction Indication option
ii. 1 logo for overload option
iii. 1 logo for no smoking option

B. Hall Fixtures: Hall fixtures shall be provided with necessary push buttons and key switches for elevator operation

Hall fixtures shall feature square mechanical illuminated buttons marked to correspond to the landings, in raised fixture housings. Buttons shall be projecting in vertically or horizontally mounted fixture. Hall Lanterns and Position indicators shall be illuminated by means of vacuum fluorescence. Fixture shall be brushed stainless steel finish.

C. Car Lantern and Chime: A directional lantern visible from the corridor shall be provided in the car entrance. When the car stops and the doors are opening, the lantern shall indicate the direction in which the car is to travel and a chime will sound.

D. Hall Position Indicator centered above the entrance at all landings.

25.11 Green Technology

ReGen drives:

ReGen drives or equal approved need to be provided to expand on the efficiency of the elevators, reducing energy consumption by 75 percent. Conserving energy that is normally wasted as heat during braking. These drives should capture this energy and feed it back into the building's electric grid for use by other building systems, such as lighting, there by delivering "clean power", which minimizes impact on the building's electrical system and helps protect sensitive building equipment. The energy efficiency of the elevators shall be in Class 'A'.

The system used shall be **LEED** credits for energy conservation.

25.12 EXECUTION

25.12.1 Preparation

A. Take field dimensions and examine conditions of substrates, supports, and other conditions under which this work is to be performed. Do not proceed with work until unsatisfactory conditions are corrected.

25.12.2 **Installation**

25.12.2.1 Installation of all elevator components as specifically provided with all requirements to complete the work in an operation condition.

25.12.2.2 The contractor shall be responsible for all civil works and to modify the shaft of the elevator to suit the elevator dimension.

25.12.3 **Demonstration**

A. The elevator contractor shall make a final check of each elevator operation with the Owner or Owner's representative present prior to turning each elevator over for use. The elevator contractor shall determine that control systems and operating devices are functioning properly.

SCHEDULE OF ELEVATORS

1. ELEVATOR FOR 12 (Twelve) PERSONS

A.	TYPE	Passenger
B.	NO. OF UNITS	As per Drawing
C.	ELEVATOR NO.	As Per Drawing
D.	CAPACITY	900 Kg. (12 Persons)
E.	SPEED	1 mps
F.	RISE	As per drawing
G.	STOPS	As per drawing
H.	OPENINGS:	As per drawing
I.	FLOOR MARKINGS:	As per drawing
J.	DRIVE:	ACVVVF Gearless
K.	MACHINE ROOM LOCATION:	Machine roomless / with machine room
L.	HOISTWAY CLEAR INSIDE:	As per drawing
M.	CAR CLEAR INSIDE:	1400 MM (W) x 1500 mm(D) x 2300mm (H) as minimum
N.	DOORS:	Automatic 2 Panel-center opening

O.	CLEAR DOOR OPENING:	800 mm (W) x 2100 mm (H)
P.	PIT DEPTH:	As per drawing
Q.	OVERHEAD CLEARENCE:	As per drawing
R.	OPERATING SYSTEM:	Simplex full collective
S.	SIGNAL FIXTURES:	Car and hall buttons Car position indicator Combined hall button, hall position indicator, and direction arrows
T.	INTERCOM:	2-station communication system One in car control panel, another in guard room.
U.	EMERGENCY LIGHT IN CAR:	Emergency light with charger & battery
V.	FACILITIES TO BE PROVIDED:	Independent service Emergency fireman service Automatic Rescue Operation with battery backup
W	BUILDING POWER SUPPLY:	415V, 3-phase, 50Hz
X	BUILDING LIGHTING SUPPLY:	240V, 1-phase, 50Hz

Y **ENTRANCE FINISHES**

	FIXTURES :	Hairline stainless steel
	FRAMES :	Main Floor Narrow. Hairline stainless steel Other Floors Narrow. Hairline stainless steel
	DOORS:	Main Floor Hairline stainless steel Other Floors Hairline stainless steel
	SILLS:	Aluminum

Z. **CAR FINISHES**

	CEILING:	In Hairline stainless steel with LED spot lights or as per manufacturer's standard.

FRONT RETURN PANEL:	Hairline stainless steel
CAR OPERATING PANEL:	COP in the car side panel
SIDE PANELS:	Hairline stainless steel
REAR PANEL :	Hairline stainless steel
DOOR :	Hairline stainless steel
FLOOR COVERING:	Granite flooring

2. **ELEVATOR FOR 10 (Ten) PERSONS**

A.	TYPE :	Passenger
B.	NO. OF UNITS:	As per Drawing
C.	ELEVATOR NO.:	As Per Drawing
D.	CAPACITY:	800 kg (10 persons) as minimum
E.	SPEED:	1 mps
F.	RISE:	As per drawing
G.	STOPS:	As per drawing
H.	OPENINGS:	As per drawing
I.	FLOOR MARKINGS:	As per drawing
J.	DRIVE:	ACVVVF Gearless
K.	MACHINE ROOM LOCATION:	Machine roomless
L.	HOISTWAY CLEAR INSIDE:	As per drawing
M.	CAR CLEAR INSIDE:	1100 mm (W) x 1400 mm (D) x 2300 mm (H) as minimum
N.	DOORS:	Automatic 2 Panel-centre opening
O.	CLEAR DOOR OPENING:	800 mm (W) x 2100 mm (H)
P.	PIT DEPTH:	As per drawing
Q.	OVERHEAD CLEARENCE:	As per drawing

R.	OPERATING SYSTEM:	Simplex full collective
S.	SIGNAL FIXTURES:	Car and hall buttons Car position indicator Combined hall button, hall position indicator, and direction arrows
T.	INTERCOM:	2-station communication system One in car control panel, another in guard room.
U.	EMERGENCY LIGHT IN CAR:	Emergency light with charger & battery
V.	FACILITIES TO BE PROVIDED:	Independent service Emergency fireman service Automatic Rescue Operation with battery backup
W	BUILDING POWER SUPPLY:	415V, 3-phase, 50Hz
X	BUILDING LIGHTING SUPPLY:	240V, 1-phase, 50Hz

Y **ENTRANCE FINISHES**

FIXTURES :	Hairline stainless steel
FRAMES :	Main Floor Narrow. Hairline stainless steel Other Floors Narrow. Hairline stainless steel
DOORS:	Main Floor Hairline stainless steel Other Floors Hairline stainless steel
SILLS:	Aluminum

Z. **CAR FINISHES**

CEILING:	In Hairline stainless steel with LED spot lights or as per manufacturer's standard,
FRONT RETURN PANEL:	Hairline stainless steel
CAR OPERATING PANEL:	COP in the car side panel
SIDE PANELS:	Hairline stainless steel
REAR PANEL :	Hairline stainless steel
DOOR :	Hairline stainless steel

FLOOR COVERING: Granite Flooring

1. ELEVATOR FOR 8 (eight) PERSONS

A.	TYPE :	Passenger
B.	NO. OF UNITS:	As per Drawing
C.	ELEVATOR NO.:	As Per Drawing
D.	CAPACITY:	630 kg (8 persons)
E.	SPEED:	1 mps
F.	RISE:	As per drawing
G.	STOPS:	As per drawing
H.	OPENINGS:	As per drawing
I.	FLOOR MARKINGS:	As per drawing
J.	DRIVE:	ACVVVF Gearless
K.	MACHINE ROOM LOCATION:	Machine roomless
L.	HOISTWAY CLEAR INSIDE:	As per drawing
M.	CAR CLEAR INSIDE:	1100 mm (W) x 1400 mm (D) x 2300 mm (H)
N.	DOORS:	Automatic 2 Panel-centre opening
O.	CLEAR DOOR OPENING:	800 mm (W) x 2100 mm (H)
P.	PIT DEPTH:	As per drawing
Q.	OVERHEAD CLEARENCE:	As per drawing
R.	OPERATING SYSTEM:	Simplex full collective
S.	SIGNAL FIXTURES:	Car and hall buttons Car position indicator Combined hall button, hall position indicator, and direction arrows
T.	INTERCOM:	2-station communication system One in car control panel, another in guard room.
U.	EMERGENCY LIGHT IN CAR:	Emergency light with charger & battery
V.	FACILITIES TO BE PROVIDED:	Independent service Emergency fireman service

		Automatic Rescue Operation with battery backup
W	BUILDING POWER SUPPLY:	415V, 3-phase, 50Hz
X	BUILDING LIGHTING SUPPLY:	240V, 1-phase, 50Hz

Y **ENTRANCE FINISHES**

FIXTURES :	Hairline stainless steel
FRAMES :	Main Floor Narrow. Hairline stainless steel
	Other Floors Narrow. Hairline stainless steel
DOORS:	Main Floor Hairline stainless steel
	Other Floors Hairline stainless steel
SILLS:	Aluminum

Z. **CAR FINISHES**

CEILING:	In Hairline stainless steel with LED spot lights or as per manufacturer's standard,
FRONT RETURN PANEL:	Hairline stainless steel
CAR OPERATING PANEL:	COP in the car side panel
SIDE PANELS:	Hairline stainless steel
REAR PANEL :	Hairline stainless steel
DOOR :	Hairline stainless steel
FLOOR COVERING:	Granite flooring

4. ELEVATOR FOR SERVICE (21 Persons)

A.	TYPE	Service and Messenger
B.	NO. OF UNITS	As per Drawing
C.	ELEVATOR NO.	As Per Drawing
D.	CAPACITY	1600 Kg. (21 Persons)
E.	SPEED	1 mps
F.	RISE	As per drawing
G.	STOPS	As per drawing
H.	OPENINGS:	As per drawing

I.	FLOOR MARKINGS:	As per drawing
J.	DRIVE:	ACVVVF Gearless
K.	MACHINE ROOM LOCATION:	With machine room
L.	HOISTWAY CLEAR INSIDE:	As per drawing
M.	CAR CLEAR INSIDE:	As per latest British standards
N.	DOORS:	Automatic 2 Panel-centre opening
O.	CLEAR DOOR OPENING:	1200mm x 2000mm
P.	PIT DEPTH:	As per drawing
Q.	OVERHEAD CLEARENCE:	As per drawing
R.	OPERATING SYSTEM:	Simplex full collective
S.	SIGNAL FIXTURES:	Car and hall buttons Car position indicator Combined hall button, hall position indicator, and direction arrows
T.	INTERCOM:	2-station communication system One in car control panel, another in guard room.
U.	EMERGENCY LIGHT IN CAR:	Emergency light with charger & battery
V.	FACILITIES TO BE PROVIDED:	Independent service Emergency fireman service Automatic Rescue Operation with battery backup
W	BUILDING POWER SUPPLY:	415V, 3-phase, 50Hz
X	BUILDING LIGHTING SUPPLY:	240V, 1-phase, 50Hz
Y	**ENTRANCE FINISHES**	
	FIXTURES :	Hairline stainless steel
	FRAMES :	Main Floor Narrow. Hairline stainless steel Other Floors Narrow. Hairline stainless steel
	DOORS:	Main Floor Hairline stainless steel Other Floors Hairline stainless steel
	SILLS:	Aluminum

Z. **CAR FINISHES**

CEILING:	In Hairline stainless steel with LED spot lights or as per manufacturer's standard.
FRONT RETURN PANEL:	Hairline stainless steel
CAR OPERATING PANEL:	COP in the car side panel
SIDE PANELS:	Hairline stainless steel
REAR PANEL :	Hairline stainless steel
DOOR :	Hairline stainless steel
FLOOR COVERING:	Granite flooring

26. INDUSTRIAL PARALLEL REDUNDANT UPS COMPLETE WITH & BATTERY CHARGER

1. GENERAL

1.1 SUMMARY

This Specification describes the requirements for a Digital Uninterruptible Power system (UPS) consisting of Two single module UPS units that to be working as standalone (parallel redundant) systems. The UPS shall automatically maintain AC power to the critical load within specified tolerances, without interruption during failure or deterioration of the mains power supply (for a specified duration as per battery run time). The UPS shall be expandable by paralleling additional modules of the same rating, to provide for module redundancy or load growth requirements.

The manufacturer shall design and furnish all materials and equipment to be fully compatible with electrical, environmental, and space conditions at the installation sites that otherwise complies with local OHS and with wiring practices. The UPS shall include termination facilities to properly interface with the input AC power source and with the intended load. The UPS shall be designed for unattended operation except where operator start-up acknowledgement is required for safety reasons. The UPS shall not require any operator to be electrically skilled.

2. SYSTEM DESIGN

2.1 General

UPS equipment shall be of solid state and designed in compliance with IEC 62040. The equipment shall consist of rectifier, battery charger, standby battery cells, inverter, static bypass switch and manual bypass switch (if applicable) to form a complete working system. The UPS equipment shall meet the following performance requirements:

(a) Input

i.	Voltage	:	240V(±□15%) 50Hz (±□5%) 1-phase 2-wire or 415V (±15%) 50Hz (±5%) 3-phase 4-wire
ii.	Maximum total harmonic distortion (THD of input current	:	Requirements as stipulated in the Code of Practice fo Energy Efficiency of Electrical Installations
iii.	Power factor	:	0.95 or better

(b) Output

i.	Voltage	:	240V 1-phase 2-wire or 380V 3-phase 4-wire
ii.	Frequency	:	50 Hz ± 0.1% (free-running) 50 Hz ± 2.0% (synchronized)
iii.	Voltage regulation	:	±□1.5% at balanced load ±□2.0% at 100% unbalanced load (3-phase UPS) ±□3.0% at 100% load step change, settling time <20 ms
iv.	Wave form	:	Sinusoidal
v.	Maximum THD of output voltage	:	< 3% for linear load < 5% for non-linear load
vi.	Crest factor	:	3:1 or better
vii.	Load power factor range	:	Capacitive to inductive over the entire range, rated at 0.8 lagging

viii.	Output efficiency	:	88% or above at 50 - 100% load under online Operation
ix.	Overload capability	:	125% for 10 minutes
x.	Electromagnetic emission	:	Class A - UPS to IEC 62040-2
xi.	Maximum noise level	:	50 dB(A) at 1 metre : UPS ≤ 7.5 kVA 60 dB(A) at 1 metre : UPS □□7.5 kVA
xii.	Cold starting	:	Startup of UPS by standby battery in the absence of mains supply input

2.2 Rectifier & Inverter

The UPS System shall consist of the following standard components and features:

A. Rectifier/charger: incoming AC power shall be converted to DC by an active rectifier. The rectifier/charger shall be a high-frequency Pulse-width modulation (PWM) design, using Insulated Gate Bi-polar Transistors (IGBTs). The DC power then shall supply power to the inverter. In the event of AC power failure, the inverter shall be supplied power, without interruption, by the battery. During normal operation, the battery shall be charged by the rectifier.

   i. Total harmonic distortion of the input current must be less than 3% at full load. The above figure shall be guaranteed by active THD correction design techniques, with no additional filter stage at the rectifier input.

   ii. Input power factor must be > 0.99 at full load as minimum. The above figure shall be guaranteed by active power factor control design techniques, with no additional filter stage at the rectifier input.

   iii. Rectifier/charger regulation on each unit shall ensure DC output voltage fluctuations of less than 1% and shall take into account the ambient temperature of the battery cabinet, to set the proper charging voltage, in order to maximize battery life. Charger control logic shall as well limit battery charging current to the maximum value advised by battery vendor (sealed lead-acid batteries).

B. Inverter: the inverter shall convert the DC power at its input to regulated AC power using pulse-width-modulation (PWM) techniques and IGBTs. The regulated output of the inverter shall supply power to the critical load.

   i. **Output Voltage**: the inverter output voltage is specified in paragraph 240/415 VAC, 3-phase, 4-wire plus ground.

ii. **Voltage Regulation**: the inverter steady-state output voltage regulation shall be within +/-1 % of nominal output voltage.

iii. The UPS shall be capable of supplying an overload power of 125% for 10 min on inverter.

iv. **Nonlinear loads**: the inverter shall be capable of supplying nonlinear loads up to 3:1 crest factor.

2.3 Battery Charger

The battery charger shall have constant voltage boost charge and float charge modes with current limiting and battery temperature compensation to prevent excessive charging of the battery. Switching between the two charge modes shall be automatically to provide fast recharging without affecting the service life and Performance of the battery. The battery shall be fully charged in less than 10 hours after a stored energy time discharge. Harmonic smoothing devices shall be provided for reducing the harmonic contents in the battery charging current.

2.4 Standby Battery

The standby battery shall be integrated with the UPS equipment to provide at the time mentioned in the bill of quantity. The battery cells shall be maintenance free sealed type battery cells to IEC 61056 or IEC 60898. The minimum working life of the battery cells at 20°C shall be as follows:

(a) Charge/discharge cycles at 100% depth of discharge: 300
(b) Continuous float charging: 10 years

2.5 Static Bypass Switch

A static bypass switch shall be provided to facilitate uninterrupted and automatic transfer of the UPS load to an alternative bypass source in the event that the UPS is overloaded or faulty. The transfer of the load back to the UPS output shall be automatic when the fault is cleared and the UPS is in normal services. The UPS output and the alternative a.c. mains shall be synchronized in frequency and phase to ensure the operations of the static bypass switch will be continuous. Double wound isolation transformer shall be provided for the alternative a.c. mains. UPS equipment of rating less than 7.5 kVA may have one common input for the normal and alternative a.c. mains. The static bypass switch shall be fuse protected with an overload withstand capability of 500%.

2.6 Manual Bypass Switch

A manual bypass switch of suitable rating shall be provided for equipment maintenance and testing. The manual bypass switch shall be mechanical type with make-before-break mechanism to transfer the UPS loads to the alternative a.c. mains without supply interruption.

2.7 Protection

The UPS shall be provided with integral protective devices and control circuits to protect the equipment against:

(a) Voltage surges
(b) Over-temperature
(c) Overload, short-circuit and earth faults of input, output and battery supply
(d) High or low d.c. voltage
(e) Reverse battery polarity
(f) Other internal or external faults

In addition, automatic back feed protection shall be provided for the UPS mains input terminals to prevent electricity back feed in stored energy mode of operation.

2.8 Control and Monitoring

The UPS equipment shall include the following control and monitoring facilities:
(a) Mains on/off switch
(The UPS electronics, a.c. mains inputs and standby battery supply shall be completely isolated at the mains switch 'Off' position)
(b) Manual bypass switch

(c) Alarm reset/buzzer mute switch

(d) Indicating lights for load %, battery charge %, 'UPS On' and 'Mains Available'

(e) Audio and visual alarms for 'Mains Failed', 'On Battery', 'On Bypass', 'Low Battery' and 'UPS Fault'.

(f) Volt-free output contacts for 'Mains Failed' and 'Low Battery'

(g) Input contacts for 'Emergency Power Off' for complete shutdown of the UPS.

(h) A RS-232 serial port to transmit all available UPS alarms and status indications to computer (communication and interface software shall be provided if specified in the Particular Specification)

For UPS rated at 7.5 kVA or above, the following additional facilities shall be provided:

(i) Volt-free output contacts for 'UPS On', 'On Battery', 'On Bypass' and 'UPS

Fault'.

(j) Input contacts for 'Bypass Inhibit' for blocking the static bypass switch in case of an unstable alternative a.c. mains.

(k) Integrated measurement system and backlit LCD display unit with access buttons for display of the following information:

(i) Remaining battery backup time in minute (under current load)
(ii) Mains input phase voltages
(iii) UPS output phase voltages
(iv) UPS output frequency
(v) Battery voltage
(vi) Battery charge/discharge current
(vii) Fault diagnostic and alarm messages

3. CONSTRUCTION

The UPS equipment shall be accommodated in a rigid metal framework suitable for floor standing. The enclosure shall have a degree of protection of IP20 to IEC 60529. The UPS equipment shall be natural air cooled or forced air ventilated to suit its output rating. UPS rated at 7.5 kVA or above with forced air ventilation design shall be provided with integrated cooling fans in redundant configuration complete with monitoring instruments for the fan units and output contacts to initiate alarm on 'Fan Failure'.

The UPS equipment shall be suitable for continuous operation without de-rating under ambient temperature of 0°C - 40°C, relative humidity of 0 - 95% and altitude up to 1000 m above sea level. The UPS enclosure shall be fabricated from mild steel sheet with epoxy powder paint finish and lockable access doors.

Unless otherwise specified, UPS equipment of 2.5 kVA or less shall be equipped with two 13A 3-pin output socket outlets to BS1363 and one 2 m detachable power supply cord.

For fixed UPS equipment, a detachable brass cable gland plate shall be provided to facilitate bottom or top cable entry as specified in the Particular Specification.

4. Works Test

The UPS equipment shall be tested at manufacturer's works to demonstrate that the equipment fully complies with the specification and performance criteria.

The contractor shall be responsible for conducting any tests as may be required to clearly demonstrate that the supplied equipment complies with the Specification. Any such tests shall be deemed to have been allowed for in the tender price. The minimum requirements for tests on the UPS equipment are listed below:

(a) Tests to verify compliance with IEC 62040.

(b) Demonstrate the output characteristics of the UPS equipment at 0%, 50% and100% rated load at minimum, nominal and maximum a.c. and d.c. input voltages under online operation and stored energy modes.

(c) Demonstrate the overload capability and automatic bypass switch operations.

(d) Short-circuit test.

(e) Demonstrate the output transient response with a 100% load application and rejection by measuring the output voltage and current with storage oscilloscope.

(f) Measurement test on the maximum THD of input current and output voltage with 0 - 100% load at minimum, nominal and maximum d.c. voltage.

(g) Running test to verify the stored energy time during a complete discharge-charge-discharge cycle

(h) Operational checks of all alarms, indications, controls and protection facilities.

5. Approved Manufacturers:

A. The UPS System must be original manufactured in Europe, Japan, Korea or USA, and shall be approved by MEW.

B. The Batteries must be original manufactured in Europe, Japan, Korea or USA.

C. The UPS manufacturer shall have an authorized local agent in Kuwait with staff 24 hours 365 days call center for technical and emergency support by manufacturer trained and certified engineers.

D. The authorized local agent in Kuwait for UPS system must have done similar kind of contract and maintenance of similar UPS system in Kuwait, it should be proved by providing the project reference list.

E. The UPS and battery manufactured under license approved by original manufacturer are accepted.

F. The local agent of UPS manufacturer in Kuwait must have store with all required and necessary spare parts.

Attn:

The manufacturer of UPS shall be UL approved list and the UPS shall be tested by Third Party at Factory before shipping to Kuwait.

27. EARTHING AND BONDING

27.1 Performance Objectives:

To provide sufficiently low impedance, this will ensure the satisfactory operation of protective devices under fault conditions.

To ensure that living beings in the vicinity of substations and electrical equipment are not exposed to unsafe step and touch potentials under steady state or fault conditions.

To retain system voltages within reasonable limits under fault conditions (such as lightning, switching surges or inadvertent contact with higher voltage systems), and ensure that insulation breakdown voltages are not exceeded.

To limit the voltage to earth on conductive materials which enclose electrical conductors and equipment.

To stabilize the phase to earth voltages under steady state conditions and to dissipate electrostatic charges, which might build-up under certain conditions.

To eliminate persistent arcing ground faults.

To ensure the operation of the primary protective devices when a fault occurs between the high and low voltage windings of a transformer.

To provide an alternative path for induced current and thereby minimize the electrical "noise" in cables.

The earthing system shall include earth electrodes (solid copper or stainless steel) to provide connection to the general body of the earth and all conductors and connections to all electrical equipment and metallic structures to site. The earth electrodes shall limit the potential rise under fault conditions and buried conductors shall be provided to limit potential differences on the site and adjacent to the site to ensure safety to people and animals.

Provide an equi-potential platform on which electronic equipment can operate.

27.2 Design Parameters:

The system shall be designed and installed to provide a safe and effective earthing system in accordance with the specified standards, which include BS-7671, BS-7430, BS-6651, IEC 479, BS 6701, IEEE 80, BSEN 62305, BSEN 50164 and applicable local regulations such as those issued by MEW, MTC and other relevant organizations.
Each site and/or building shall be provided with a totally integrated system protecting the whole of the power system(s) from the main incoming power supply to the end-

user equipment. The integrated system(s) shall comprise of the MEW incoming mains earthing system, Communications and IT equipment earthing, Generator earthing, Static earthing, Lightning Protection systems and any other special earthing systems. Where there are separate buildings on the same site, these shall all be interconnected to create a site-wide integrated earthing system.

Structural metalwork in piles, foundations and superstructure shall form an important part of the integrated earthing system. Ensure proper cathodic protection a method if steel is used as earth electrode. All such metalwork shall be bonded together and connected to the perimeter earth conductor at earth electrode locations as shown in the drawings

The earthing system provided by MEW is a TN-S system by definition according to BS 7671 & IEEE 80. However there is a MEW requirement to provide separate additional consumer earthing at the boundary of the supply intake. This modifies the system to that of a TN-S/TT combination.

The document covers the design of earthing systems, conductor arrangements, conductor sizing, and power system neutral earthing for new installations and modifications and extensions to existing installations.

The maximum touch and step potentials and earth leakage currents shall not exceed those specified in the applicable standards. The attainable step and touch potential shall be lower than the tolerable level, derived from IEEE 80 equations. Earth fault currents shall be sufficient to operate the protective devices as specified in the applicable standards. Ensure the potential rise in telecommunications circuits due to power system earth faults is limited according to BS 6701.

The sizing and spacing of earth electrodes, PE conductor, bonding conductors and lightning protection air terminals and down conductors shall be such sufficient to meet the above requirements. Provide calculations to substantiate the sizing.

The maximum short circuit current allowable in Copper conductors shall not exceed the recommendations in BS 7430.

Detailed drawings, Installation details and calculations shall be provided in accordance with the appropriate standards and to the approval of the Engineer.

The overall resistance of the integrated earthing system to the mass of earth shall not be more than 0.5 ohm and shall comply with the specified requirements for the maximum touch and step potentials, earth leakage currents and operation of the protective devices.

27.3 **System Description**

The system shall comprise of various elements and components as described in the enclosed specification.

For existing installations check earth continuity conductors and loop impedance values. Report defects and elements not in accordance with the specified standards before connecting new or modified installations to existing systems.

28. LIGHTNING PROTECTION SYSTEMS SPECIALIST:

Lightning protection system shall be designed by the manufacturer of the material and as per latest British Standard.

Engage an earthing and lightning protection systems specialist to carry out the Design, Installation, Testing and commissioning of the earthing and bonding systems. This shall be done in coordination with the requirements for section “Lightning protection” and “Surge protection devices”.

29. MAINTENANCE MANAGEMENT SYSTEM (MMS)

Contractor shall provide MMS software (original approved) within Twenty (20) months of signing the contract. A penalty of KD.100/- shall be imposed for everyday of delay, starting from the 20 months due date.

The software shall be capable of alerting when the maintenance is due, preparation of work orders automatically, generation of weekly/monthly report of all activities; maintain equipment data, history and cost. The operation and maintenance of the software shall be carried out by the contractor’s project engineer for planning and follow-up. The contractor shall supply two (2) nos. latest computers and two (2) nos. LaserJet colour printers to MEW engineer’s office, in addition to the hardware required to be installed in maintenance room. MEW engineer shall be able to access the various reports generated by the software through internet from his office computer.

A. Planned Preventive Maintenance on Maintenance Management System Program:

The contractor shall provide computer program for maintenance similar to MMS for PPM routines classified as Weekly (W), 2-Weekly (2W), Monthly (M), 3-Monthly (3M), 6-Monthly (6M), Annual (A) and occasional (0). They shall also include those routines based on completed running hours of the equipment for, e.g., 500 hourly routine, 1000 Hourly routine, 5000 Hourly routine, 10,000 Hourly routine and shall submit weekly report to MEW engineer. If the contractor failed to submit weekly maintenance report to the MEW engineer as specified above, KD. 100/- per day

shall be imposed as penalty. The contractor shall provide training for 12 (twelve) personnel for two weeks at site for Preventive Maintenance Programme.

B. If the contractor during the maintenance period fails to respond to any necessary repairs called by MEW within 24 hours after being notified, MEW reserves the right to impose penalty KD. 200/- per day per fault and execute the repair under the full responsibility of contractor and charge the contractor the cost of those repairs without accepting any claims from the contractor's side.

30. BUS DUCT

A. MANUFACTURER

1. Manufacturer shall be a company specialized in manufacturing the products specified in this section with minimum ten years of experience. The manufacturer should have local engineering, site service support…etc. either directly or through their local agent.
2. For the equipment specified herein, the manufacturer shall be ISO 9001:2008, OHSAS 18001:2007 and ISO 14001:2004 certified.
3. Subject to full compliance with this specification, the contractor is to submit complete technical analysis from any of the following manufacturer to the Owner/ Engineer for approval.

    1. Zucchini
    2. Siemens, Germany
    3. Eaton Electric
    4. Schneider Electric
    5. GE

B. GENERAL

1. Furnish and install a complete low impedance pre-fabricated busway system as shown on the drawings including all necessary fittings and supports whether or not indicated on the drawings or defined in detail in these specifications.
2. The complete system including busduct, Transformer connections, accessories, supports, tap-off units, Elbows, Tees, Flange end, Offsets and circuit breakers should be from one manufacturer.
3. The low voltage busway and all components shall be designed, manufactured and tested in accordance with the latest applicable standard IEC61439-6, edition 1.0
4. Submit below listed complete Type Test Certificates on design verification annex D as per latest IEC 61439-6 standards for each proposed busway ratings from one of the following independent third party testing agency Intertek (ASTA),

DEKRA (KEMA). Test report shall be for the product offered and belong to the plant, manufacturing proposed product.

- Verification of strength of material and parts (clause 10.2)
- Verification of the degree of protection (clause 10.3)
- Verification of clearances and creepage distances (clause 10.4)
- Verification of protection against electric shock and integrity of protective circuits (clause 10.5)
- Verification of incorporation of switching devices and components (clause 10.6)
- Verification of Internal electrical circuits and connections (clause 10.7)
- Verification of terminals for external conductors (clause 10.8)
- Verification of dielectric properties (clause 10.9)
- Verification of temperature-rise limits (clause 10.10)
- Verification of short circuit withstand strength (clause 10.11)
- Verification of electromagnetic compatibility (EMC) (clause 10.12)
- Verification of Mechanical Operation (clause 10.13)
- Verification of resistance to flame propagation (clause 10.101)
- Verification of fire barrier in building penetration (clause 10.102)

5. In order to guarantee final product quality, each busway section shall have KEMA KEUR or ASTA Diamond. Necessary supporting documents shall be provided to confirm that the busway manufacturing plant is inspected and under ongoing surveillance by the above mentioned testing bodies.
6. Busduct shall be manufactured to comply with IEC 61439-6. It shall be suitable for 3 phase, 4 wire, 415 Volt, 50 Hertz system. Busduct shall have full capacity neutral and 50% capacity integral ground bus. Busway and all accessories shall have 1000V as rated voltage (Ue) and rated insulation voltage (Ui).
7. The ampere ratings shall be as indicated on the drawings. The busduct shall be suitable for mounting in any position without derating. Every piece of busway has to undergo 7.5kV hi-pot test at the factory before shipping and test records should be produced to confirm these.
8. It is the sole responsibility of the contractor, without any cost implication to the project owner, to upsize the busway ratings wherever required to meet 55degC ambient temperature, 65KA/1sec fault level or as per short circuit level at the point of installation and voltage drop requirements as per project specification & MEW regulations.
9. The busbar trunking system should pass seismic tests with actual physical product and being certified complying with UBC seismic Zone 4 condition by an international recognized earthquake research body, e.g. Asian Pacific Network of Centers for Earthquake Engineering Research (ANCER).
10. The voltage drop (input voltage minus output voltage) specified shall be based on the busway operating at full rated current and at stabilized operating temperature.

The three-phase line-to-line voltage drop shall not exceed 4% at full connected load. Provide calculation to substantiate the limits.

11. Install 100mm high waterproof curb around each floor openings where busway passes through.
12. Install weather seal and expansion joint where busway penetrates external wall or roof.

C. BASIC CONSTRUCTION

Busbars:

1. Busbars shall be of hard drawn high conductivity copper of 99.9% purity with silver-plated throughout the length or aluminum with copper cladding utilized Molecular Fusion technology. Silver plating only on joints of copper busbars will not be accepted. There shall be no bolts passing through the busbars of the busway system.
2. Busbars shall be insulated over their entire length including elbows, except at joints and contact surfaces, with Class B, 130 deg C, by two layers of polyester film like mylar on each phase. Insulation used should be recyclable.
3. The busway shall be capable of carrying rated current continuously without exceeding a temperature rise of 55degC. Apply necessary derating factor to achieve full rated current of the busway at 55 deg C. ambient temperature.

Housing:

1. The busbar trunking housing shall be totally enclosed non-ventilated for protection against mechanical damage and dust accumulation.
2. The busway and associated fittings shall be compact size, sandwich structure which consist of silver plated copper conductors totally enclosed of extruded, electrical grade aluminum as a two piece design to reduce hysteresis and eddy current loses along with code gauge steel for mechanical strength which shall be provided with a suitable protective finish of ANSI 49 gray epoxy electrostatic powder finish
3. The housing shall have passed at least 500 hours salt spray test to ensure the anticorrosion ability. Outdoor feeder, indoor feeder and indoor plug-in of same rating shall be interchangeable without the use of special adapters or splice plates.
4. Fittings shall be identical for use with both the plug-in and feeder types of busway. The busway shall be capable of being mounted in the flatwise, edgewise or vertical positions without derating. Provide one hanger for every 2mtrs of horizontally mounted busway or as recommended by manufacturer. On vertical

runs provide one spring, suspension type hanger per floor and at the end of the bus run on the last floor.

5. The degree of ingress protection shall be IP54 for indoor and IP66 for outdoor busway as per IEC 60529.
6. Earth continuity at joints shall be achieved by boltless, continuous earth design which should be integral part of the busway enclosure. Bolted parts in any form on the enclosure to achieve earth continuity will not be accepted.

Joint:

1. Each busway section shall be furnished complete with a factory installed removable joint. The specially made monoblock joint pack assembly shall be a single, double headed bolt, non-rotating design, double silver plated contact surface which shall be removable from the side without disturbing adjacent sections of the busway.
2. All bridge joints shall be furnished with torque-indication at ground potential, double-headed single bolt whose outer head will shear off at rated torque using standard spanner. The second head will remain to allow joint maintenance or busbar relocation.
3. The bridge joint shall utilize a Belleville washer to provide equal pressure across the complete joint contact area for proper electrical contact without temperature rise. Access shall be required to only one side of the busway for tightening joint bolts.
4. Each bridge joint shall allow itself for a, ±3mm adjustment in section length at each joint connection for thermal expansion.
5. De-energization of the busway shall not be required for safe testing of joint tightness.
6. It shall be possible to remove any joint connection assembly to allow electrical isolation or physical removal of a busway without disturbing adjacent busway lengths.

Plug-In Openings:

1. Where required, busway shall be of plug-in type. Plug-in outlets shall be provided on both sides of the busway. Plug in busway shall be three dead front, hinged cover type plug-in opening at approximately 600mm interval. Plug-in outlet covers shall prohibit dirt and debris from entering the plug-in contact opening in the busway to retain the IP rating.
2. The connecting jaw of the plug-in unit shall plug directly onto the busbar of busway and have full contact with busbar itself. Welded or reverted tab at plug-in busbar is not allowed. All openings shall be usable simultaneously.

3. Plug-in and feeder busway of the same ampere rating shall have identical short circuit withstand ratings. Busbar trunking shall be installed so that plugs are side mounted to permit practical use of all plug-in openings.
4. It shall be possible to inspect the plug-in opening and busbars prior to the installation of the plug-in units. Plug in opening when cover removed, shall comply with IP2X for safety of the operator. Positive mechanical guides for plug-in units shall be provided at each plug-in outlet to facilitate unit alignment and prevent improper installation.
5. Plug-in outlets shall be furnished with barriers across the plug-in openings to prevent accidental contact with a live part by an operator or installer.

D. PLUG-IN UNITS (TAP-OFF UNITS)

1. Where required, tapoff units of the types and ratings indicated on the contract drawings shall be supplied. Tap off units shall be fitted with suitably rated MCCB's as shown in the drawing from the same manufacturer of busway.
2. Tappoff units should have been type tested in accordance with IEC 61439-6 standards. Test certificates shall be furnished along with submittal.
3. Tapoff unit's upto 500A shall be plug-in type and above 500A shall be bolt-on type. Only one tapoff opening of the busway shall be used for all tap of units irrespective of current rating. Tapoff units shall be mechanically interlocked with the busway housing to prevent their installation or removal while the switch is in the ON position.
4. The ground stab of any plug-in unit shall make a positive connection with a busway ground contact, inside the plug-in outlet, before the phase and neutral stabs make contact with the contact surfaces of the bus bars.
5. All plug-in units shall be equipped with a defeatable interlock to prevent the cover from being opened while the switch is in the ON position and to prevent the accidental closing of the switch while the cover is open.
6. The plug-in units shall be equipped with internal transparent barriers to prevent any accidental contact of internal busbar connections or live parts. The operating mechanism and handle shall remain in control of the disconnect device at all times, permitting easy operation from the floor by means of a hookstick.
7. For safety reasons, no projections shall extend into the busway housing. All plug-in units shall be interchangeable without alteration or modification to the busway. Molded Case Circuit Breakers installed in tap off units shall have minimum 65KA Ics ratings or equallent to busway's short circuit rating and shall all be of current limiting type.
8. The plug-in jaw shall be spring design composed of different metal to ensure the firm and tight contact with the busway busbar even during temperature fluctuation. Only busbar should be used on both sides to interconnect the breaker and plug-in jaws.

E. FIRE RESISTANCE:

1. The busway shall be fire resistant – not create secondary fire outbreak - as per IEC 61439-6 in the event of fire.
   - The busway shall not propagate a fire from one room to another by crossing a fire barrier wall.
   - The busway shall be resistant to flame propagation
   - The busway insulating material shall be resistant to abnormal temperatures.
2. For essential /emergency life safety circuits, which supply power to fire fighting equipment where mentioned, the circuit integrity shall be maintained in the event of fire. The fire rated busway shall be tested as standard ISO834-1 and circuit integrity shall be maintained for upto 240 mins.
3. The busway shall not generate any toxic emission in the event of fire. The busway shall be designed such as to ensure very low smoke and zero halogen in the event of a fire to give better visibility aiding the rescue operation and enabling the EXIT path to be seen clearly for escape.

F. EXECUTION

1. Busway and tapoff units shall be installed complete with all necessary fittings and hardware in accordance with manufacturer's instructions. Particular care shall be taken to ensure that the bolted connections are properly torque and that adequate allowance is made for expansion where necessary.
2. Fire barriers shall be installed at floor and wall penetrations as required according to KFD requirements.
3. Delivery to the site shall be in original manufacturer's packing and carefully stored and suitably protected in a dry, dust free secured area until ready for installation.
4. Each section of busbar trunking system shall have the ends protected by suitable means from the manufacturer prior to delivery to prevent damages during transportation and storage. The sections shall be securely wrapped overall in tough poythene film to prevent moisture ingress and dust accumulation. The protection shall be removed only prior to installation.
5. In vertical runs of busbar trunking, the sections between each floor level shall be separately supported with purpose made spring supports provided by the manufacturer designed to take the weight of the section of the busbar trunking between the floors. It shall be possible to remove any section of busbar trunking without disturbing the remainder of the system.
6. Any joint or section of busbar trunking, which are left exposed or not connected after completion of day's work, shall be protected in accordance with the manufacturer's instructions to ensure that there is no possibility of dust or water entering before closure.

7. Ensure that the required clearances are maintained between the adjacent runs the busbar trunking runs are correctly aligned. Installation shall be done either by the manufacturer or their agent who will have manufacturer trained engineer.
8. Prior to fixing the sections, ensure that the ends of each section and the joints are clean and completely free of dust, water or any other contamination. If any contamination occurs, the contact surfaces of the sections and the joints shall be cleaned properly and strictly in accordance with the manufacturer's instructions.
9. The joint bolt shall be tightened strictly in accordance with the manufacturer's instructions. Immediately after tightening of the joint bolts the protective covers shall be fitted in place.
10. Provide fire rated barriers of approved fire-resisting materials surrounding the busbar trunking where it passes through floors and fire rated walls.
11. The insulation resistance of each section shall be measured before installation and after completing a few sections with an approved and calibrated insulation tester.
12. Contractor shall verify site dimensions and coordinate actual routings and equipment locations. Contractor shall not fabricate the busway without the approval of the shop drawings. It is the contractor's responsibility to coordinate with all services and equipments to make sure that the busway routings are accurate.
13. Certificate with a record of all the tests shall be issued by the manufacturer or his authorized representative prior to energizing the busbar trunking system.

31. 63A BUSBAR TRUNKING SYSTEM WITH SWITCHED SOCKET OUTLETS PLUG-IN-TYPE

General

Description *:*

The trunking shall have 3 compartments within its profile with provision for an interlocking extension trunking compartment i.e. two compartments with facilities for carrying telecommunication, data services with the central compartment containing busbars for power outlets and related switch control accessories. There shall be a cable way above for hard wiring and extension compartment below for additional cable space complying in all respects with the 16th Edition of the IEE Wiring Regulations.

Composition and Manufacture :

31.1 Trunking

Should be made of Extruded UPVC.

31.2 Trunking Fittings

The system shall have a comprehensive range of couplers, end plates, internal and external corners, both horizontal and vertical, electrical and ELV accessories.

31.3 Shape and Size

The trunking shall have three compartments-two outer compartments mainly for ELV cables with a third central compartment containing the busbars with a cable way above. It shall be possible to fit the extension to the bottom compartment only.

31.4 Fire

The system shall be fabricated from non- flame propagating material in accordance with BS 476 Part 7 and shall have a class 1Y classification.

31.5 Chemical Resistance

The system must be non-corrosive and shall be unaffected by sea water. It should be resistant to mineral acid, alkalis and detergents.

31.6 Degree of Protection

The system enclosure classification must be to IP 41 (BS 5490), when installed in accordance with the instructions set out in the Installation Guide, which must be made available by the supplier.

31.7 Thermal

The system must be designed to accommodate thermal expansion and contraction when installed in accordance with the instructions set out in the Installation Guide.

31.8 Busbar rating

63A 250V AC

31.9 Recommended Manufacturer :

Powerlink Plus Busbar Trunking System from MK1963WHI or equivalent.

32. FLOOR OUTLET BOX

Standards	**IEC 61084-1::1991** **93/68/EEC** **73/23/EEC** **IEC 61084-2-2 : 2003**
Operating temperature	-25 - 60°C
The lid shall be at least 3 mm pre-galvanized or stainless sheet steel load plate with 6mm carpet recess.	
IP degree of protection	IP20
Type of floor	Raised floor
Floor Box shape	Rectangular
Colour	Grey
Material	All material shall be fire resistance, halogen free.
Dimension:	
Length	340mm - 400 mm as minimum
Height	100mm – 130 mm as minimum
Width	200mm – 250 mm as minimum
Number of compartment	Compartment fully segregated.

Each floor outlet box shall be furnished by the manufacturer of the outlet box with the following: -

- Twin BS 1363 switched socket for normal power supply complete with 1 No. 15A mcb with built-in earth leakage 30m A.
- Twin BS 1363 switched socket for emergency power supply with clean earth complete with 1 No. 15A mcb with built-in earth leakage 30m A.
- Telephone outlet as per M.O.C Standard specification.
- Data outlets for computer networks.
- TV outlets.

Note: The Floor outlet Box shall match with Raised Floor Tiles.

The approved manufacturers shall be: -

Legrand - France

Schneider Electric - France

M.K. - UK

SOCOMEC, France

Floor Box System (FBS) USA

Hitachi - Japan

or equal approved from USA, JAPAN, WEST EUROPEAN Make and Test Certificate shall be provided from international approved laboratory.

33. WITHDRAWABLE INTELLIGENT MOTOR CONTROL CENTERS (IMCC)

This specification describes the requirements for the low voltage intelligent motor control centre (IMCC). The IMCC is the equipment that provides comprehensive protection on motors by integrating intelligent motor protection relays (IMPR) or intelligent protection devices (IPD) inside the MCC switchboard. The IMCC should also bundle the bus communication with the most common protocols found in industrial networks (Modbus SL / Modbus TCP / Profibus DP / DeviceNet).

The IMCC offer should comply with the related national and international standards, including, but not limited to:

- IEC 60439-1
- IEC 60529
- IEC 60947

The IMCC should be an equipment offer labelled with the brand name of an international company (IMCC designer), which owns the complete intellectual property of the iMCC switchboard and intelligent devices used in this offer. The IMCC should be a complete range, which provides the flexibility to choose different solutions in motor protection and monitoring functions according to the requirements of critical motors and non-critical motors and related loads.

The IMCC original designer should be a worldwide well-known leader in electrical distribution and automation; it should have a rich experience in project execution, including switchboard design, manufacturing, installation and commissioning in-house or by licensed partners; it has the capability to provide training, technical support and service at a worldwide level. The know-how on both the switchboard and

the protective devices should guarantee the availability and the reliability of the equipment.

Related Documents:
Drawings and general provisions of contract, including general and supplementary conditions apply to this section.

33.1 Quality Assurance

A. Applicable Standards referred to in this Section:

IEC 60439-1	Type tested assemblies for LV switchgear Voltages not exceeding 1000 V ac.
IEC 60439-3	Distribution Boards
IEC 60947-2	ACB's, MCCB's
IEC 60947-2, IEC 60898	MCB's
IEC 60144	Direct Acting Meters
IEC 60831-1 & 2	Power factor correction capacitor
IEC 60664 & IEC 1010-1	Power factor regulator
IEC 60070 & IEC 60831	Capacitor switching contactors
IEC 60289 & IEC 60076	Detuned reactors
IEC 60947-4	Motor Starters
IEC 60947-4	Contactors
IEC 60529	Degrees of protection of enclosures
IEC 364 and IEC 755	Earth Leakage Relays
IEC 60947-1 and 60947-4	Overload Relays

33.2 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract.

1 Product data for each product and component submit also relevant sheets of manufacturer's catalogues.

2. Shop drawings for each switchboard including dimensioned plans and elevations, component and device lists, and a single-line diagram showing main and branch bus current ratings and short-time and short-circuit ratings of switchboard.

3. Shop drawings or other descriptive documentation of optional barriers specified for electrical insulation and isolation.

4. Shop drawings of utility company metering provisions with indication of approval by utility company.

5. Schedule of features, characteristics, ratings, and factory settings of individual protective devices.

6. Manufacturer's Schematic Wiring Diagram.

7. Point-to-point Control Wiring Diagram: Differentiating between manufacturer-installed and field-installed wiring.

8. Mimic Bus Diagram and colour samples shall be submitted to all Motor Control Centres. Submit updated version of diagram reflecting field changes after final switchboard load connections have been made.

9. Installer Certificate Signed by Third Party: The signed technician for the mimic bus meets the experience / qualifications specified under "Quality Assurance".

10 Qualification data for field-testing organisation certificates, signed by the Contractor, certifying that the organisation complies with the requirements specified in Quality Assurance below. Include list of completed projects with project names, addresses, names of Architects and Owners, plus other information specified.

11. Report of field tests and observations certified by the testing organisation. Also include a statement that equipments offered comply with the relevant specifications.

12. Discrimination study between upstream and downstream breakers shall be carried out using software namely ETAP/ Ecodial etc and submitted the Engineer for approval.

33.3 Products

33.3.1.1 Manufactuers of Components

Subject to compliance with requirements, provide products and LV enclosure system by the following:

1. Schneider Electric
2. Siemens
3. ABB
4. Moeller Electric
5. Toshiba
6. Mitsubishi
7. General Electric

The complete switchboard including enclosure parts, busbar supports, circuit breakers, motor starters, major switchgear components, etc shall be from one single principal manufacturer only. Local assembly / local adaptation are allowed however keeping in line with requirements of IEC standards and ensuring local adaptations done do not affect type testing results of prototype.

33.3.1.2 Switchboard Manufacturer

The switchboard manufacturer could be the **equipment plant of the IMCC original designer** or a panel builder with a formal **license** from the IMCC original designer. **All switchgear used in the switchboard shall be of the same manufacturer to allow better interoperability and installation.**

33.3.1.3 Features and certificates

(a) Type tests

The IMCC switchboard must be a **Type Tested Assembly (TTA)**, compliant with IEC 60439-1. The switchboard type-test **certificates shall be originated by a worldwide known third-party certification organization such as ASEFA, or KEMA**. The supplier should be able to provide several certificates (not only one) upon request during the project. These certificates should either reflect the switchboard characteristics or allow understanding on how these characteristics are reached. In this second case, **the manufacturer shall be able to show design tables (such as derating or co-ordination tables) formally originated from the IMCC original designer.**

The selected switchgear and controlgear brands shall be equal to the ones mentioned in the type tests reports of the equipment.

(b) Internal arc features

The switchboard should be designed to minimize the risks of occurrence of an internal arc, and whenever such an arc occurs it should prevent its effect on operators and material/equipment surrounding the switchboard. It should be in conformance with the requirements of AS 3439-1.

(c) Seismic features

The switchboard should have the capability to withstand seismic conditions. When the switchboard is to be used in a seismic area, the manufacturer should determine the switchboard configuration according to seismic information provided by customer, which is appropriate to the stresses involved. The seismic test should be done in compliance with the UBC (Uniform Building Code) and CBC (California Building Code) regulations. The manufacturer shall be able to provide information on seismic zone (1 to 4) and installation level which the equipment is conforming to.

(d) Corrosive atmosphere features

The switchboard should have the ability to **withstand corrosion due to Sulphur Dioxide (SO_2) and Hydrogen Sulphide (H_2S)** with necessary adaptations recommended by the iMCC original designer. Inside the equipment, the appropriate coating should be done on conductors (busbars, connections) and metal elements (mechanisms, frames, casing). Also, the electrical and electronic equipment should show a compliance class relevant to the above pollutants. The manufacturer shall consider the power circuits' conductivity depending on the types of coatings used on these circuits. Upon request, the manufacturer shall be able to show the iMCC original designer specifications regarding the above mentioned facts.

The level of protection on the switchboard will be in conformance with IEC 721-3-3.

33.3.1.4 Electrical and mechanical characteristics

(A) Electrical

- Rated insulation voltage : 1000 Vac
- Rated operational voltage : up to 690 Vac
- Rated current of main busbar : up to 6300A
- **Short current withstand strength : 65kA/1s**
- **Internal arc withstand : 85 kA**

(B) Mechanical

- Form: Form 3b
- IP: IP 54
- Cable Entry: Top / Bottom
- Access: Front / rear
-

33.3.2 **General**

a. The supply and distribution arrangement shall be as indicated on schematic diagrams in the Drawings.

b. Evidence of country of origin should be produced on request.

c. Motor Control Centre, MCC shall be type tested as per IEC 60439-1 by the original manufacturer or local assembler.

The prototype assemblies shall conform to the following 7 type test defined in IEC 60439-1:-

i. Verification of temperature rise.
ii. Verification of dielectric properties.
iii. Verification of short circuit withstands strength.
iv. Verification of the effectiveness of protective circuit.
v. Verification of clearances and creepage distances.
vi. Verification of mechanical operation.
vii. Verification of degree of protection.

Type test Certificate on prototype from independent laboratory or internationally accredited laboratory done by the original equipment manufacturer will be submitted for approval.

33.3.3 Switchboard structure

(a) Busbar

To facilitate the connections and cable access, the main busbar should be installed at the top or bottom of the columns, with the design allowing for front or back cables' connection, via the top or bottom plates. All these interfacing possibilities should remain available even with no busbar position change.

The main busbar should be made of copper bars spliced at each column level in order to achieve simplicity and flexibility in transportation, installation and maintenance. Sliding fishplates should be used to make the connection of the copper bars between columns.

(b) Functional units (FU)

The IMCC offer should provide diverse functional units according to the different application requirements. Full withdrawable functional units must be available for motor starters to achieve easy operation and maintenance.

There should be clear position indicators of the drawer, which indicate the connected, test and disconnected position. **The drawer should provide an effective mechanical latch to prevent incorrect operation to avoid unexpected position changing from one position to another.** The drawers should have the feasibility to be locked by 3 padlocks to prevent unauthorized insertion/withdrawal or OPEN / CLOSE operation.

In case those two drawers are of the same dimensions there shall be, as an option, a mechanical mean to prevent unwanted interchangeability of these drawers. Software-only means will not be accepted.

The size of functional units should be optimised to achieve high stacking density of switchboard. The switchboard shall have the capability to accommodate 23 drawers of 9kW with bus communication.

(c) Derating

To ensure that all components work in appropriate conditions, the influence of the ambient temperature and switchboard IP must be taken into account in the design of the switchboard. To ensure the reliability, the switchboard manufacturer must be able to provide, when requested, the derating table of starters, formally originated from the iMCC original manufacturer showing the current value allowed for the dedicated components under a certain combination of ambient temperature, IP degree and voltage.

(d) Starter compartment

The starters inside the MCC (DOL/Star-Delta) shall be in fully withdrawble trays. VFD / Soft starter shall be constructed in fixed compartments. Front blank drawers shall be supplied to cover the compartment during maintenance.

33.3.4 General requirements for IMPR

(a) IMPR supplier

The IMPR supplier should have a valid ISO 9001 (2000 version) certification and a certified quality assurance system. The supplier shall have the Environment Certification ISO 14001 and shall be able to supply the Product Environmental Profile (P.E.P) upon customer request.

The supplier must have a local representative office with qualified support staff to provide training, technical support and service.

(b) Functionality

Please refer to following clauses for the IMPR function requirements of critical motors and non-critical motors.

(c) Communication

The IMPR should provide the communication ports for the connection to the communication network. It should be easily integrated into the communication architecture with remote information access.

It shall be an open communications system, which means that it shall be directly connected to the main industrial network protocols, listed below:

- ModBus SL

- ModBus / Ethernet

- Profibus DP

- DeviceNet

The IMPR should embed the relevant network protocol in built-in (native) mode.

(d) Configuration

The IMPR supplier should provide user-friendly software running in a Windows environment to ease the IMPR on-relay configuration. The software should have menus and icons for easy access to the data required, guided navigation to go through all the data of the same function in one screen and with a file management system.

(e) Protection

The IMPR should provide protection on the following faults with alarm setting:

- Thermal overload
- Current phase imbalance
- Current phase loss
- Current phase reversal
- Long start
- Jam (locked rotor during running)
- Under current

- Over current
- Ground current
- Voltage phase imbalance
- Voltage phase loss
- Voltage phase reversal
- Under voltage
- Over voltage
- Under power
- Over power
- Under power factor
- Over power factor

IMPR should support direct motor thermal protection by supporting temperature sensor (PTC Binary or PTC Analogue or NTC Analogue) input.

IMPR should provide “Rapid cycle lockout” mechanism to prevent inadequate motor start.

IMPR should support “Voltage load shedding” to set up motor re-starting sequence when power voltage is unstable.

The thermal overload trip curve shall be selectable between inverse (I^2t) or definite time (I;t) curve. For variable speed drives, auxiliary fan cooling application should also be proposed according to specifications from the iMCC original designer.

It shall include Ground Fault Protection internally, and **it shall be possible to use an external toroid CT to do it, without any additional module or device.**

(f) Metering

The IMPR should provide the following measurement, statistics and diagnostic functions to implement different applications and carry out commissioning and maintenance.

- Measurement
  - Line current
  - Average line current
  - Current phase imbalance
  - Ground fault current
  - Thermal capacity level
  - Motor internal temperature (sensor input)

- Frequency
- Line-to-Line voltage
- Line voltage imbalance
- Active power
- Reactive power
- Active power consumption
- Reactive power consumption

- Statistics
  - Protection fault counts
  - Protection warning counts
  - Diagnostic fault counts
  - Motor control function counts
  - Fault history

- Diagnostics
  - Internal watchdog results
  - Controller internal temperature
  - Temperature sensor connections
  - Current connections
  - Voltage connections
  - Control commands (start, stop, run, check back and stop check back)
  - Control configuration checksum
  - Communication loss

- Motor States
  - Operating time
  - Motor starts per hour
  - Maximum current of last start
  - Last start time
  - Time to trip
  - Time to reset

The manufacturer shall be able to propose at least one solution with direct current sensing (without current transformer) up to 100 A.

For motors bigger than 100 A, external current transformers should be provided.

(g) Monitoring

The IMPR should provide the monitoring and diagnostic functions of the following:

- Diagnostic

- Run command check
- Stop command check
- Run check back
- Stop check back

- Wiring / configuration faults
  - PTC connection
  - CT reversal
  - Voltage phase reversal
  - Current phase reversal
  - Voltage phase loss
  - Phase configuration

- Internal fault
  - Stack overflow
  - Watchdog
  - ROM checksum
  - EEROM
  - CPU
  - Internal Temperature

- Motor temperature sensor
  - PTC Binary

  - Thermal overload
  - Definite
  - Inverse Thermal

  - Current
  - Long Start
  - Jam
  - Current Phase Imbalance
  - Current Phase Loss
  - Over current
  - Under current
  - Internal ground current
  - External ground current

  - Voltage
  - Over voltage
  - Under voltage
  - Voltage phase

- Imbalance

- Power
- Under power
- Over power
- Under Power Factor
- Over Power Factor

(h) Operating mode

IMPR should support the following motor operating modes:

- DOL (Independent)
- Star-Delta (Two steps)
- Two directions (Reverse)
- Custom Mode (via programming)

(i) Programming

The IMPR shall provide a “Custom mode”, allowing control logic to be customised by the manufacturer or the end user.

33.3.5 IMPR for non-critical motors

It is acceptable to use an intelligent motor protection device, including circuit breaker, contactor sensing and processing unit in a single component. However, all the IMPR used in the IMCC should be from the same manufacturer.

(a) Protection

The IMPR should provide the following protections and alarm settings:

- Thermal overload trip, with selectable tripping class 5, 10, 15, 20, 25,30
- Over current trip
- Under current trip
- Jam trip
- Phase imbalance trip
- Long start trip
- Internal fault trip

(b) **Measuring**

The IMPR shall provide measurement on motor current, including:

- 3 phase current
- Average current
- Thermal capacity
- Phase imbalance

(c) Monitoring

The IMPR shall provide monitoring on motor status, including:

- Starting count
- Running hours
- Fault count and identificationLast 5 faults history log

33.7 Quality Control Testing Program: Conform to the following:

1. Program Objectives: To assure switchboard installation meets specified requirements, is operational within specified tolerances, provides appropriate protection for systems and equipment, and is suitable for energising.

2. Procedures: Make field tests and inspections and prepare switchboard for satisfactory operation in accordance with manufacturer's recommendations and these specifications.

3. Schedule tests and notify Engineer at least one week in advance of test commencement.

4. Reports: Prepare written reports of test results and observations. Report defective materials and workmanship, Include complete records of adjustments and remedial efforts.

5. Labelling: Upon satisfactory completion of tests and related effort. Apply a label to tested components indicating test results, person responsible, and date.

6. Protective Device Ratings and Settings; verify indicated ratings and settings and make the final system adjustments of Overcurrent Protection Devices.

33.8 Visual and Mechanical Inspections: Include the following Inspections and related work:

1. Inspect for defects and physical damage, testing laboratory, labels, and nameplate compliance with up-to-date circuit connections.

2. Verify that potential transformers, including their overcurrent protection and current transformers meet specified requirements.

3. Perform operational test and exercise of mechanical components and other operable devices in accordance with manufacturer's instruction manual.

4. Check switchboard anchorage, area clearances, and alignment and fit of components.

5. Check tightness of bolted electrical connections with calibrated torque wrench. Refer to manufacturer's instructions for proper torque values.

6. Clean switchboard interior and exterior-using manufacturer's approved methods and materials.

7. Perform visual and mechanical inspection and related work for Overcurrent Protective Devices.

33.9 Electrical Tests: Include the following items performed in accordance with manufacturer's instruction:

1. Insulation resistance test of buses and portions of control wiring that disconnect from solid state devices through normal disconnecting features.

2. Ratio and polarity tests on current and voltage transformers.

3. Ground resistance test on system and equipment ground connections.

4. Verify appropriate capacity, overcurrent protection, and operating voltage of control power elements including control power transformer and control power wiring.

5. Check phasing of alternate supply sources to the same bus.

6. Test over-current protective devices as specified for compliance.

7. Retesting: Correct deficiencies identified by tests and observations and retest switchboards. Verify by the retests that switchboards meet specified requirements.

33.10 Cleaning

Upon completion of installation, inspect interior and exterior of switchboards. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and marks of finish to match original finish.

33.11 Protection

Temporary Heating: Apply temporary heat in accordance with manufacturer's recommendation within each section of switchboards throughout periods during

which the switchboard is not in a space that is continuously under normal control of temperature and humidity.

33.12 Demonstration

Training: Arrange and pay for the services of factory-authorized service representatives to demonstrate switchboards and train Owner's maintenance personnel.

INTELLIGENT DALI (DIGITAL ADDRESSABLE LIGHTING) DIMMING SYSTEM

A. Scope of Work

The contractor shall design, supply and connect DALI intelligent Dimming system including the following: -

1) DALI control gear for each light fitting.

2) Rotatory or touch dimmer with ON/OFF switch for each room (ie. Office, meeting room, etc.).

3) All required software.

4) All required hardware including PLC, Computer, sensors, wiring, cables, timer, occupancy detection, conduit, lighting control panel, modification of electrical installation, …etc.

5) Interface with Integrated Building Management System and Fire Alarm system.

6) All required to complete the work in an operation condition.

B. DALI Dimming system shall supply by LED down light fitting manufacturer and warranty of 5 (five) years starting from commissioning date.

C. The dimming system warranty shall be a writeen warranty from both the supplier and the agent including replacement of defetcted units at site.

34. STREET LIGHTING WORKS

1. General:

This specification is to be read in conjunction with the “Standard Specifications for Street & External Lighting Works, March-1990”, issued by the Ministry of Electricity & Water; the various standard drawings listed therein, this particular specification and the contract drawings listed elsewhere in this specification.

Should there be any difference between the Standard Specifications and Particular

Specifications, then the Particular Specifications shall prevail.

2. Scope:

The street lighting works of the project include for the manufacture, supply, erection, commissioning and maintenance of the network and shall include for all concrete foundations, excavation and backfilling, PVC ducting, cabling, compacting/leveling, provision of handholes, earth-pits and earth electrode devices, road crossing ducts, etc., along with all other components and accessories that are required for completing the works.

The Contractor shall note that the street lighting system for the project incorporates energy saving features by employing dual power dimming ballasts and power switching devices including all wiring/cabling from the feeder pillars to the lighting units in order to centrally and automatically control the lumens output to dim from 100% to 50% at a pre-set time during the night and back to full lumens output at early morning through an astronomical time switch installed at the feeder pillar. Since the contractor has to provide all these additional equipment, wiring/cabling, etc. to make the system fully operational with energy saving feature, it is extremely important that he should study the specifications very carefully before submitting his bid for this tender.

3. Design Drawings:

The street lighting scheme for the roadways included in this contract are described in the drawings as indicated below:

(a) Proposed Street Lighting, Al-Mutlaa High Water Reservoirs Area – Phase 2. Drg. Nos. PSL-1438

The Electrical Subcontractor shall prepare detailed working (shop) drawings of the project and obtain approval of the Ministry of Electricity & Water Engineer before starting and carrying out any work at site.

4. Standard Drawings of MEW:

The Electrical Subcontractor shall obtain from the Ministry of Electricity & Water, the latest revisions of the following standard specifications and drawings and strictly adhered to the same in carrying out the street lighting works under the Contract.

A. Standard Specifications for Street & External Lighting Works, March-1990, issued by the Ministry of Electricity & Water, Kuwait.

B. Standard Drawings of MEW listed in the above Standard Specifications.

C. Standard Drawing No. N/1/168 - Details of Concrete Foundations for Lighting Columns, PVC Ducting, Handholes and Earth-pits.

D. Standard Drawing No. N/1/170 - Details of Concrete Foundation for Feeder Pillar, Manhole & Protective Crush Barrier.

E. Should there be any difference between the Standard Specifications and Particular Specifications, then the Particular Specifications shall prevail.

5. Working Drawings:

The Electrical Subcontractor shall submit for approval of the MEW Engineer, detailed working drawings. The design drawings are giving an approximate location only of the lighting units and feeder pillars in the area. The Subcontractor shall make a detailed survey of the area prior to preparing any working drawings. The working drawings shall be prepared with AutoCAD to Scale 1:1000, 1:2000 or as directed by the Engineer in A-1 size only and submitted in three (3) copies minimum.

Works at site must not be started until and unless approval is gained for all the working drawings and details from the MEW Engineer.

6. Special conditions for safety regulations, for individuals, properties and utilities:

6.1 Maintenance of Traffic:

The Contractor shall keep all existing roads open all times for Traffic. If in the opinion of the Engineer temporary road closures are required, the Contractor shall:

A. Execute the work at the time when the traffic is least.

B. Provide safe path-way for pedestrians and vehicles.

C. Provide in all cases, fencing, signs, light signals, flood light and watchmen to ensure that no mishaps befall the public or properties.

6.2 Services coordination:

The Electrical Subcontractor shall notify in all cases and obtain necessary clearances from other Ministries and Authorities in case their services might be affected by his works in order to take necessary measures by the concerned beforehand.

6.3 Existing services:

The Electrical Subcontractor shall refer to all relevant Civil, Sewage, Drainage, Telephone, EHV/HV/LV Cable route and all other services drawings and obtain for himself the exact locations and position of various services, so that in the execution of his work, he will not disturb or damage any other services and additionally shall maintain adequate and specified clearance between street and external lighting and all other services.

The Electrical Subcontractor shall also refer to and comply with the current regulations and specifications of Ministries, Authorities and Companies before commencing any works adjacent to equipment, plant, cables etc.

The above requirement will not relieve the Electrical Subcontractor of his responsibility for taking every precaution to avoid damage to equipment, plant, cables etc. and he will be held responsible for the cost of repair of all damages.

6.4 Safety regulations:

The Electrical Subcontractor shall strictly abide by all safety rules and regulations issued by the Authorities like Kuwait Municipality, Traffic Department, MEW, M.P.W. M.O.C., M.O.I. and others, and shall provide in all cases, steel fencing, warning tapes, signs, light signals, flood lights and watchmen to ensure that no mishaps befall the public or properties.

6.5 Public safety and convenience :

The Electrical Subcontractor shall not deposit the earth obtained from excavation of trenches and foundations and/or store up or deploy equipment, tools and plant necessary for the work in locations which affects the safety of the public or public services or properties.

7. Site Office:

The Electrical Subcontractor shall provide, install and furnish with all required logistic supports, a fixed, portable or mobile site office to accommodate offices for his own engineer and staff in addition to the offices for the MEW Engineer and supervisory staff. The site office shall be to the entire satisfaction of the MEW Engineer in all respects and any modification required shall be carried at no extra cost whatsoever. He shall also provide three nos. of mobile phones with line to be used by his staff for the entire duration of the contract.

The Bill of quantities does not include any items or quantities for the site office to be supplied, installed and furnished, but the Electrical Subcontractor shall provide for

these as part of the contract works.

8. Sign Boards:

The Electrical Subcontractor shall erect minimum three (3) Nos. of painted wooden signs, each 2 metres wide by 1.5 metres high with the bottom of the sign set at 1.4 metres above ground level. The sign layout and support system shall be designed by the Electrical Subcontractor and must be approved by the MEW Engineer prior to erection of the signs at locations, which are a safe distance from adjacent pavements, as directed by the Engineer.

The signs shall have the nature of the works, the Employer and the Electrical Subcontractor lettered thereon in Arabic and English. No other signs or advertisements will be permitted on the site. The sign board shall be maintained in good condition repainted as necessary and removed when no longer required.

The Bill of quantities does not include any items or quantities for the signboards to be supplied and erected for the project, but the Electrical Subcontractor shall provide for these as part of the contract works.

9. MATERIALS:

All materials shall comply with the Standard Specifications and the Amendments included herein under this Particular Specifications of the Project.

A. The Subcontractor shall submit all materials along with full technical details for the approval of the MEW Engineer before placing any orders.

B. Only materials from MEW approved list of of street light ing manufacturers will be considered.

10.1 10 M. GALVANIZED STEEL STREET LIGHTING COLUMNS:

The 10 metre lighting columns shall be exactly as specified in the standard specifications except as amended herein.

A. The lighting columns including all base compartment doors, brackets, anchor bolts, frames, etc., shall be fabricated form high quality structural steel. The Grade of steel as per BS: 4360 shall be minimum 50B and the steel shall have a minimum tensile strength of 490 N/sq. mm. and yield strength, 355 N/sq. mm.

B. All columns shall be hot-dip galvanized, both internally and externally to BS EN ISO 1461: 1999 except that the mean coating thickness of galvanizing shall be 85 microns as a minimum. All brackets, anchoring frames shall be hot-dip

galvanized.

C. The base compartments shall be fitted with flush or over-lapping type hinged doors and high heat resistant silicon rubber gaskets having a minimum thickness of 4 mm. shall be provided all around for weather-proofing to comply with the protection category of minimum IP 33 to IEC:60529. The galvanized steel hinges shall be minimum 3mm thick and 3 Nos. of 80 mm. Long hinges shall be provided for each door. The dia. of the hinge pin shall be minimum 5 mm. and the hinge leaves shall be continuously welded all around to the body of the column and the door in an aesthetic manner subject to the Engineer's approval. The centre hinge shall be reversed to make the doors non- removable.

D. Stainless steel hinges may be considered by the Engineer provided they are of a very high quality and the Subcontractor is ready to submit a guarantee stating that the hinges will not corrode in 25 (twenty-five) years time and if anycorrosion occurs within this period they will replace and re-fix all hinges at no extra cost whatsoever. The stainless steel hinges shall be of the same dimensions and thickness as stated above for the galvanized steel hinged and shall be fitted to the body of the column and the door by at least 2 Nos. high quality stainless hexagonal socket head steel bolts, two nuts and necessary plane and spring washers.

E. The steel frame around the door opening shall be 25 mm. by 8 mm. which shall be continuously welded all around.

F. The flange plate shall be continuously welded to the column from inside and outside in an approved manner and four (4) Nos. of gusset plates shall be provided. The size of the gusset plates shall be 150 mm x 90 m x 10 mm. (Th.) for 10 metres lighting columns, which shall be continuously welded to the body of the column and the flange plate.

G. The Manufacturer's name, Contract No. and date of manufacture shall be marked at the front side of the flange plates with minimum 1 mm deep engraving or punching.

H. The Electrical Subcontractor shall obtain and submit the following guarantees from the manufacturer on their original letterhead duly signed and stamped.

i) Guarantee that the designed life time of the lighting columns is for minimum twenty-five (25) years from the date of installation at K uw ait 's extreme weather and wind conditions stipulated and if any lighting column fails within this period, the same will be replaced and reinstalled free of charge.

ii) That the galvanized steel hinges will not break within a period of twenty- five (25) years and if any hinge breaks within this period, the same will be replaced and repaired free of charge.

Without the guarantee, the lighting columns will not be accepted.

10.2 250 W. HIGH PRESSURE SODIUM CUT-OFF LUMINAIRES:

The 250 watt high pressure sodium cut-off street lighting luminaires shall be as specified in Cl. 2.1 of the Standard Specifications and as amended herein.

A. The 250 cut-off lanterns shall be designed to operate on 240 Volts, single phase, 50 Hz. supplies and to accommodate a 400 or 250 watt high pressure sodium, tubular in shape with (E40) cap. The lantern shall be equipped with an Ignitor suitable for 400 and 250 watt high pressure sodium lamps and must be complete with all internal wiring.

B. The luminaires shall be aesthetic in design, colour and shape, from a modern concept and shall have a degree or protection, minimum IP65 to IEC 60598 against the ingress of dust and moisture under all operating conditions. The control gear compartment shall have a degree of protection of minimum IP53. The colour of the luminaire must be approved by MEW.

C. The nominal overall dimensions for a 250 watt rated lantern shall be 750 mm (L) x 350 mm (W). Acceptance of any minor tolerances in the overall dimensions of the lantern is at the sole discretion of the MEW.

A. The body of the luminaire shall be pressure die cast from a very high grade of aluminium alloy and shall be of minimum thickness 2.0 mm.. The reflector shall be in one complete piece from high purity polished and anodized aluminium having a minimum thickness of one (1) millimetre.

D. The cover of the luminaire shall be clear, high heat and shock resistant, tempered glass bowl or a glass dish and the optical assembly of the luminaire shall be totally sealed without the use of any gaskets. The glass cover shall be minimum 4 mm. thick, encased in stainless steel or die cast aluminium alloy frame with substantial hinges and catches. Covers made from acrylic or polycarbonate materials and flat glass covers will not be accepted.

E. The luminaire shall be designed for lamp replacement from the backside with the use of a lamp holder cassette and a locking unit. Such components shall preferably be from non-corrosive metal fabrications. However, components made of high quality and high temperature resistance plastic materials may be considered provided such materials are guaranteed for a period of ten (10) years against any deform and damage, but again, is at the sole discretion of the Engineer and may be rejected also. Fully detailed material specifications and test certificates of the plastic shall be provided. Without the details and test certificates the offer may be rejected. The cassette shall have a collar and fitted

to the reflector with the use of adequate nos. of stainless steel screws and high temperature resistance silicon rubber gasket.

F. The side entry mounting of the 250 W. luminaires shall be 120 mm. long approximately and the luminaires shall be fitted with at least two to three numbers 10 mm. hexagonal socket head galvanized steel screws, all as approved by the Engineer.

G. All luminaires shall be provided with a 80 mm. x 45 mm. non-corrosive metal name plate of minimum thickness 1.0 mm which shall be fixed with two (2) rivets in a position where it can be easily seen, distinctly engraved in black and in 4 to 5 mm. height letters and digits with the information as specified in IEC: 60598 including the degree of protection (IP), Contract No., Project Title and the inscription “MEW’. The name plate mus t not be fi x ed to any c ontrol gear or other components.

H. All luminaires must have a Serial No. which should also be engraved on the name plate in 4 to 5 mm. height letters and digits. The Serial No. shall be started with the Contrac t N o. & Watt age of the lamp, aft er that w it h lett er “ S” for Sodium lamp and “ C ” or "S" for C ut -off or Semi Cut-off distribution and then with the Serial No. of the luminaire (e.g., Contg. No./250/SS00001). Without the Serial Nos., the luminaires will be rejected.

I. **Ignitors:** The Ignitors shall be independent superimposed type for operation on a supply voltage of 240 V (+10%/-17.5%), 50 Hz. and shall include an automatic cut-off timer system to prevent repeated re-striking of defective lamps if the lamp does not start within the available time. It shall have aluminium containers, and Pulser type ignitors and ignitors having plastic containers are not acceptable. The ignitors shall fully comply with IEC Publication No. 60926.

J. An instruction manual giving full details of the installation and maintenance procedure of the luminaire shall be provided with each luminaire carton.

K. The Electrical Subcontractor shall submit a guarantee from the manufacturer stating that the material used for the glass cover will be from high heat and shock resistant tempered glass of adequate thickness that will not break easily and will be free from effects of aging or discoloration throughout the service life under the rigorous climatic conditions mentioned in this specification. The guarantee shall also state that the luminaire is well designed for proper heat dissipation when used with a 250 w att high pres s ure s odium lamp at Kuw ait ’s extreme ambient temperature conditions and there will be no undue temperature rise inside during operation of the luminaire leading to the breaking of the glass cover, any loosening/softening/melting of the silicon paste/gaskets used, failure of degree of protection, shortening of the lamp life and/or damage of any other parts or components of the luminaire. Any luminaire that will undergo any such problem and/or breakage, damage or deform of any other kind within a period of five (5) years from the date of

installation will be replaced and reinstalled free of charge

L. The Subcontractor shall also submit a guarantee from the ignitor manufacturer to state that the offered type of ignitors will give continuous trouble free service at Kuwait 's extreme ambient temperature and weather conditions and any ignitor that will fail or burn out within a period of 3 (three) years will be replaced free of charge. Without the guarantee, the Ignitors will not be accepted.

10.3 250 W. HIGH PRESSURE SODIUM (HPS) LAMPS:

The 250 W. high pressure sodium lamps shall be as specified in the Standard Specifications and as amended herein.

A. The lamps shall be manufactured to the European standard practice and shall comply with the IEC Publication No. 60662. They shall be fully suitable for operation in conjunction with Ballast having operating characteristics as specified in this IEC, and/or IEC Publication No. 60923, except that the Rated Voltage shall be 240 volts instead of 220 volts. The lamps shall be tubular in shape with E-40 cap and clear type. The H.P.S. lamps shall operate in conjunction with an external ignitor and lamps with built-in ignitors will not be accepted.

B. The Average Rated Life or the Life Expectancy of the lamps shall be considered as the number of burning hours at 10 hours/start which have elapsed when 50 (fifty) per cent of lamps from a large batch have failed.

C. The Electrical Subcontractor shall submit a guarantee from the manufacturer of the lamps to state that any lamp that will fail or burn out within a period of two (2) years of operation from the date of installation will be replaced free of charge. Without the guarantee, the lamps will not be accepted.

D. The Electrical Subcontractor shall maintain with him a minimum stock level of 20% of the total lamps from each type under the contract to replace any failed or burnt out lamps within maximum two (2) weeks of a written intimation. In case he fails to replace the lamps within the specified time period, a penalty @ KD.2.000/Lamp/Day will be imposed on him.

10.4 CONTROL GEARS FOR HIGH PRESSURE SODIUM (HPS) LAMPS:

The street lighting control gear panels and the various components therein shall be exactly as specified in the standard specifications except as amended below.

10.4.1 DUAL POWER DIMMING BALLASTS:

The dual power dimming ballasts for all high pressure sodium lamps shall fully comply with the IEC Publication Nos. 60922 & 60923 in regard to the general, safety and performance requirements and shall be Resin encapsulated, independent type and single lamp ballasts for installing in the base compartments of street lighting columns.

A. The dual power dimming ballasts shall be designed in order that the lumens output of the lamps can be reduced from 100% to 50% at a pre-set time during the night through a power switching device operated centrally and automatically by an astronomical time switch installed at the street lighting feeder pillar, thus to achieve a saving of energy by approximately 35 to 40%.

B. The dimming ballasts shall have metal name plates as specified in the standard specifications. Name plates made of plastic material, or paper printed labels will not be acceptable. Alternatively, the particulars and connection diagram shall be directly printed on to the resin encapsulation with a permanent and non- removable type of ink.

C. The Electrical Subcontractor shall submit a guarantee from the ballast manufacturer to state that the offered type of dual power dimming ballasts will
give continuous trouble free service at Kuwait's extreme ambient temperature and weather conditions and any ballast that will fail or burn out within a period of 5 (five) years will be replaced free of charge. Without the guarantee, the ballasts will not be accepted.

D. The Electrical Subcontractor shall maintain with him a minimum stock level of 20% of the total dimming ballasts from each type under the contract to replace any failed or burnt out ones within maximum two (2) weeks of a written intimation. In case he fails to replace the ballasts within the specified time period, a penalty @ KD.10.000/Ballast /Day will be imposed on him.

10.4.2 CAPACITORS:

The terminals of the capacitors shall be screw less Terminals with push wire connectors suitable for use with insulated bootlace ferrules.

A. The Electrical Subcontractor shall submit a guarantee from the capacitor manufacturer to state that the offered type of capacitors will give continuous trouble free service at Kuwait's extreme ambient temperature and weather
Conditions and any capacitor that will fail or burn out within a period of 2 (two) years will be replaced free of charge. Without the guarantee, the capacitors will not be accepted.

10.4.3 POWER SWITCHING DEVICE:

The power switching devices will be operated centrally and automatically by an astronomical time switch installed at the street lighting feeder pillar in order that the lumens output of the lamps can be reduced from 100% to 50% at a pre-set time during the night thus saving energy by approximately 35 to 40%.

A. The switching devices shall be adequately rated and provide continuously trouble-free service at the arduous weather and temperature conditions specified. The devices shall be manufactured and tested to fully comply with the requirements of the relevant international standards.

B. The Electrical Subcontractor shall submit a guarantee from the power switching device manufacturer to state that the offered type of power switching device will give continuous trouble free service at Kuwait's extreme ambient temperature and weather conditions and any switching device that will fail or burn out within a period of 5 (five) years will be replaced free of charge. Without the guarantee, the power switching devices will not be accepted.

C. The Electrical Subcontractor shall maintain with him a minimum stock level of 20% of the total power switching devices from each type under the contract to replace any failed or burnt out ones within maximum two (2) weeks of a written intimation. In case he fails to replace the switching devices within the specified time period, a penalty @ KD.10.000/Switching Device/Day will be imposed on him.

10.4.4 CONTROL GEAR PANELS:

The overall dimensions and the thicknesses of the control gear panels shall be exactly as specified in the standard specifications except as amended below.

A. The capacitors shall be mounted in lying position with the use of mounting supports from minimum 2 mm. thick galvanized steel or Aluminium plates. The width of the supports shall be equal to the diameter of the capacitors and height, 50 mm. which shall be fixed by minimum 2 Nos. of galvanized steel screws. A single plate shall be provided for the double control gear panels with adequate clearances between the capacitors. The hook shall cover the whole width of the panel, but the projected part shall be 70 mm. for all control gear panels. The outward projection of the hook from the edge of the plate shall be 15 mm. and the lip for hanging as well as the lip attached to the plate shall be both 25 mm. wide. The hook for all control gear panels shall be fixed at the top of the panel on the backside.

B. All fixing screws for the different components shall be cross recessed

pan head screws from galvanized steel and the sizes shall be 6 mm. for the hanging hook, 5 mm. for the ballasts and 4 mm. for all other components. Screws shall be fixed from the front only with galvanized steel hexagonal nut at the back and be provided with necessary plane and spring washers. The screws employed for fixing the ballasts or any other component shall not be used for fixing the hooks.

C. Terminal blocks shall be suitable for minimum 6sq.mm. size copper conductors and shall be single unit type, fixed on mounting rails horizontally, at least 10 mm. inside from the bottom of the control gear panels. The number of terminals for the single control gear panels shall be eight (8) and for double twelve (12), all divided into phase, lamp, neutral and earth terminals as directed and approved by the Engineer. The neutral and earth terminals shall be linked internally with shrouded jumper strips fixed by screws and loop- in/loop-out wires for this will not be accepted.

D. An earth terminal from 6 mm by 20 mm. long hexagonal head brass screw with two nuts and two washers shall be provided at the bottom left corner of all the control gear panels and this will be wired to the terminal block suitably.

E. All wiring on control gear panels shall be carried out with high temperature Type-TI3 PVC (BS EN 50363-3, Table-1) insulated, 600/1000 V, single core, rigid, round and stranded (type-CR, Class-2, 7 strands), 2.5 sq.mm. copper conductor cables, all complying with the latest relevant I.E.C. and/or B.S. specifications.

F.Each dimming ballast shall be connected separately for power supply and any loop-in/loop-out connection for this will not be accepted. All connections to the terminal blocks, ballasts, capacitors, etc. shall be made with the use of proper size of insulated bootlace ferrules only and crimping tool. Bare connections without ferrules will not be accepted.

G. All control gear panels shall be provided with a 80 mm. x 45 mm. non-corrosive metal name plate of minimum thickness 1.0 mm which shall be fixed with two (2) rivets in a position where it can be easily seen, distinctly engraved in black and in 4 to 5 mm. height letters and digits with the particulars, like Contract No., Project Title, type of panel, manufacturer's name, year of manufacture and the ins c ripti on " MEW'. The name plate mus t not be fi x ed to any c ontrol gear or other components.

H. All control gear panels must have a Serial No. which should also be engraved on the name plate in 4 to 5 mm. height letters and digits. The Serial No. shall be started with the Contract No., type of control gear panel after that with letter "S" for Sodium lamp and then w it h the Serial N o. (e.g., Contg. No.1X250WS/00001). Without the Serial Nos., the control gear panels will berejected.

10.5 STREET LIGHTING CUT-OUTS:

The street lighting cut-outs shall be exactly as specified in the standard specifications except as amended below.

A. The miniature circuit breakers (MCB) of all types of cut-outs shall fully comply with IEC: 60898 and the breaking capacities specified shall be the rated short circuit (breaking) capacity as per this IEC Publication. The rated short circuit capacity of the 6 Amp MCBs shall be 3 KA minimum at 240 Volts. The circuit breakers shall meet the test requirements for the rated short circuit and service short circuit breaking capacities at the above specified values when carried out in accordance with IEC 60898.

B. The cover of the cut-out shall be fixed to the body with 5 mm. By 15 mm. long pan head galvanized steel captive screws, all as shown in the latest revision of the Drawing No. N/1/129. Screws made captive by the use of washers or circlips will not be accepted and true captive screws shall be used.

C. All terminals shall be single unit type and from Polycarbonate or Polyamide material. The earth terminal shall be from 6 mm. by 25 mm. hexagonal head brass bolt with two brass nuts and two washers.

D. The intermediate wiring between the terminals and the MCBs of the cut-outs shall be carried out with high temperature Type-TI3 PVC (BS EN 50363-3, Table-1) insulated, 600/1000 V, single core, rigid, round and stranded (type- CR, Class-2, 7 strands), 2.5 sq.mm. copper conductor cables, all complying with the latest relevant I.E.C. and/or B.S. specifications. The earth wire sizes shall be 6 sq.mm. for 6 Amp. cut-outs.

E. All connections to the terminal blocks and the MCBs shall be made with the use of proper size of insulated bootlace ferrules only and crimping tool. Bare connections without ferrules will not be accepted.

F. The cut-out shall be painted to a minimum thickness 80 Microns, when electrostatic dry power epoxy polyester method of painting is employed.

G. All cut-outs shall be provided with a 75 mm. x 35 mm. non-corrosive metal name plate of minimum thickness 1.0 mm which shall be fixed with two (2) rivets in a position where it can be easily seen, distinctly engraved in black and in 4 to 5 mm. height letters and digits with the particulars, like Contract No., Project Title, type of cut-out, manufacturer's name, year of manufacture and the ins c ripti on " MEW'.

H. The Electrical Subcontractor shall submit a guarantee from the cut-out manufacturer to state that all the cut-o ut c om po ne nts lik e MC B's , termi nals , c able gla nds , etc . w ill giv e c onti nu ous tr ou ble fr ee s erv ic e at Kuw ait 's ex t reme ambient temperature and weather conditions and any component that will fail,

malfunction or burn out within a period of 2 (two) years will be replaced free of charge.

10.6 STREET LIGHTING CABLES & WIRES:

All underground cables and flexible cables within the columns shall be from an approved cable manufacturer of the Ministry of Electricity & Water, but the Subcontractor shall submit a quotation from M/s. Gulf Cable & Electrical Ind. Co., Kuwait together with the proposed cable manufacturer's quotation, for MEW's study and approval.

A.The Electrical Subcontractor shall submit a guarantee from the cable manufacturer to state that all the offered types of cables will give continuous trouble free service at Kuwait's extreme ambient temperature and weather Conditions and any cable that will fail or get damaged within a period of three(3) Years will be replaced and reinstalled free of charge.

10.7 STREET LIGHTING FEEDER PILLARS, TYPE - E:

The street lighting feeder pillars shall be as specified in the Standard Specifications and as amended herein.

A. The overall dimensions of the feeder pillars without canopy shall be 1700 mm (H) x1050 mm (W) x 500 mm (D) and the sloping type canopy shall have a minimum depth of 100 mm. at the centre. All four sides of the canopy shall be bent inside and welded continuously with the body in an aesthetic manner. Any stitch welding for this will not be accepted.

a) Each feeder pillar shall consist of two compartments, a top compartment with double insulation and an equipment mounting panel for future installation of street lighting tele-management equipment, smart meters etc., and a bottom compartment with a separate equipment mounting panel for mounting of phase bus-bars, neutral and earth bars, MCCBs, contactors, outgoing terminals and other components, all wired and ready for use. The overall dimensions of the top compartment shall be approximately 450 mm (H) x1000 mm (W) x 400 mm (D) and the compartment shall be designed to carry heavy weights in case dimming/stabilizing transformers for saving energy are to be mounted inside it.

B. The feeder pillar shall be fabricated from pre hot dip galvanized sheet steel of minimum thickness 3 mm. having a zinc coating thickness of minimum 275 gm / sq.m (38.5 Microns).

C. The doors shall be in two vertical parts and be provided with substantial hooks to hold the doors in open position during working. The pad locking strips shall be minimum 3 mm. thick with 14 mm. dia. holes and shall be welded all around in an

aesthetic manner.

D. The window of the photo-cell shall be 150 mm x 100 mm. with suitably sized round holes on the enclosure itself and fitted with a transparent, clear polycarbonate or plexiglass plate minimum thickness 5 mm. A sliding type shutter for closing from inside shall also be provided. The ventilators shall be one at the top and one at the bottom on each side of the feeder pillar.

E. The feeder pillar shall be supplied and installed with an astronomical time switch in addition to the photo-electric cell. The astronomical time switch shall be from the latest technology, manufactured by a well-reputed renowned manufacturer to relevant international standards and shall withstand Kuwait's extreme weather and temperature conditions. It shall operate on 240 (+/-6%) Volts, 50 Hz. power supply, be rated for an electrical load of 2300 watts as a minimum and shall operate within a - 5 degree to + 80 degree centigrade temperature range. The astronomical time switch shall be programmed to function as follows:

a. The turn on with full (100%) illumination of the luminaries in the street lighting units shall occur 15 minutes after the sunset.

b. The reduction to fifty per-cent (50%) illumination shall occur at 10:00 PM during the night.

c. The full (100%) illumination shall be re-established one hour before the sunrise.

d. The turn off shall occur 15 minutes before the sunrise.

e. During the darkness at any other time during the daylight hours due to bad weather conditions, provision of overriding the time switch by the photo-cell shall be available.

f. In the event of malfunction of the astronomical time switch, it shall permit closing of contactor directly to provide full (100%) illumination.

F. The mounting channels shall be provided with holes suitable for M16 anchoring bolts at centres, 600 mm. x 360 mm. and two Nos. of separate gland plates with weather-proofing gaskets shall be provided for fixing the incoming and outgoing cable glands. The dust filters shall have standard dimensions of 150 mm. (W) x 100 mm. (H) x 4 mm. (Thick).

G. The equipment mounting panel shall from pre-hot dip galvanized sheet steel of minimum thickness of 3 mm. and shall be provided with robust stainless steel handles at the top and bottom or at the two sides. At the front of the equipment mounting panel and inside the feeder pillar, a full length second door from minimum 1.5 mm. thick galvanized or electro-plated sheet steel with necessary slots for the operating knobs of the MCCBs and MCBs shall be provided to prevent any accidental contact with bus-bars or other live material during maintenance. The single leaf door shall be hinged to the body on its left hand side by at least 4 Nos. of substantial

stainless steel hinges and shall be closed on the right by galv. steel captive screws.

H. The incoming and outgoing moulded case circuit breakers shall comply in all respects to the IEC Publication No. 60947-2 and the value of the Breaking Capacities specified shall be the Rated Services Short Circuit Breaking Capacity as per this IEC. The electro-magnetic contactor shall fully comply with the IEC Publication No. 60947-4-1.

I. The connection between the contactor and the phase bus-bars shall be by H.D.H.C. Copper Bars and the connection between the outgoing MCCB and the terminals by 35sq.mm. Type-TI3 PVC (BS EN 50363-3, Table-1) or XLPE insulated Copper cables.

J. The phase terminal blocks shall be all single unit type suitable for 35 sq. mm. copper conductors and the numbers shall be eighteen (18), with twelve (12) Nos. connected in R-Y-B phase sequence and six (6) Nos. as spares, all clamped together in an approved manner.

K. The Neutral and Earth Bars shall be provided with suitable pressure type terminals for connecting the main Neutral and the Earth conductors and the number of outgoing terminals shall be eighteen (18) Nos. each, suitable for 16 sq. mm. copper conductors.

L. The terminals shall be all pressure type only. Number of cable glands shall be eight (8) for 3-core 16 sq. mm. cables and four (4) Nos. for 5-core 35 sq. mm. cables.

M. All wiring inside the feeder pillar shall be carried out with high temperature Type-TI3 PVC (BS EN 50363-3, Table-1) insulated, 600/1000 V, single core rigid, round and stranded (type-CR Class-2, 7 strands), 2.5 sq. mm. copper conductor cables, all complying with latest relevant I.E.C and/or B.S. specifications.

N. A high quality 13 Amp. Power Socket for maintenance and test equipment shall be installed at an accessible location and shall be wired and connected together with a single pole, 16 Amp. rated circuit breaker for protecting from overload. Also, 1 No. 16 Amp. SP & 1 No. 16 Amp. TP MCB shall be provided for 24-hour power supply.

O. Each feeder pillar shall be provided with a 120 mm. x 50 mm. non-corrosive metal name plate of minimum thickness 1.0 mm which shall be fixed with two (2) rivets at the front of the left hand side door, distinctly engraved in black and in 4 to 5 mm. height letters and digits with the particulars, like Contract No., Project Title, type of feeder pillar, manufacturer's name, year of manufacture and the inscription " MEW'.

P. Two (2) Nos. of 200 mm. x 150 mm. electrical danger signs of approved type, also from non-corrosive metal plates shall be fixed with two (2) rivets on the feeder pillars, one at the front of the right hand side door and the other at the back side of the feeder pillar.

Q. All fixing screws for the different components shall be from galvanized or stainless steel of adequate size. The manufacturer shall submit a written guarantee to state that the various fixing screws for different components will not corrode during the life time of the feeder pillars and twenty-five (25) years as a minimum. In case any of the fixing screw will undergo problem of corrosion or any other form of deterioration, the same will be replaced and fixed free of charge throughout the lifetime of the feeder pillars.

R. The feeder pillar after fabrication shall be applied with a two-component polyamide cured zinc-rich epoxy primer (Hempadure Zinc 15360 or equivalent) to a dry film thickness coating of minimum 40 microns and then with a final coat of paint by using electrostatic dry powder epoxy polyester method of painting to a film thickness of 80 microns.

S. The Electrical Subcontractor shall submit a guarantee from the feeder pillar manufacturer to state that all the feeder pillar components like MCCB's, MC B's, Contactors, Selector Switches, Photo-cells, Astronomical Time Switches etc. will give continuous trouble free service at Kuwait's extreme ambient temperature and weather conditions and any component that will fail, Malfunction or burn out within a period of 2 (two) years will be replaced free of charge. The manufacturer shall also guarantee that if painting of the feeder pillars is damaged or deteriorated within a period of 5 (five) years, all feeder pillars will be repainted free of charge. Without the guarantee, the feeder pillars will not be accepted.

T. The Electrical Subcontractor shall maintain with him a minimum stock level of 20% of the total astronomical time switch under the contract to replace any failed or faulty time switch within maximum two (2) weeks of a written intimation. In case he fails to replace the time switch within the specified time period, a penalty @ KD.50.000/Time Switch/Day will be imposed on him.

U. The Electrical Subcontractor and feeder pillar manufacturer shall be fully responsible for proper functioning of the specified logic controls of the lighting systems/Astronomical time Switch and three (3) Nos. of complete programming/software kits shall be provided free of charge.

V. The astronomical time switch units including its functioning/programming to the specified logic controls shall be maintained by the Electrical Subcontractor and feeder pillar manufacturer for a period of five (5) years from the date of installation without any extra cost whatsoever.

11. APPROVAL OF MATERIALS AND EQUIPMENT:

11.1 TECHNICAL SUBMISSION:

On award of the contract, the Contractor shall submit for approval by the Engineer the name of the manufacturer, the catalogue reference number and full manufacturer's technical literature for each major item of equipment to be supplied for the lighting and electrical works under the Contract together with fully completed and signed technical schedules attached to this particular specifications, fully dimensional drawings, applicable design calculations and computer print-outs for lighting levels of typical installation details as per the MEW's Standard Street and External Lighting specifications.

A. The items of equipment shall include, but not be limited to:

- Lighting Columns
- Luminaires
- Lamps
- Cables
- Control Gear Panels
- Cut-outs
- Feeder Pillars
- Earth Rods

B. Where items of equipment submitted by the Subcontractor are not approved by the Engineer, the Subcontractor shall submit details of alternative equipment if necessary supplied by different manufacturers, until the Engineer's approval is gained.

11.3 MATERIAL SAMPLES:

i) The Electrical Contractor shall provide the materials' samples for MEW approval.

ii) The Electrical Contractor shall submit samples of the following items for MEW approval.

- Bottom section of lighting columns with one hinged door.
- Types of luminaires proposed for use
- Types of lamps
- Cut-outs
- Earth rod
- Handholes & Manholes
- Types of cables & wires.
- Controlgear panels
- UPVC ducts
- All types steel forms for civil works.

iii) In addition to the above, the Electrical Contractor may be required to submit samples of any other materials for approval and to carry out any test if so required and asked by MEW. <u>All samples will be retained by MEW and will</u> <u>not be returned.</u>

12. INSPECTION AND TESTING:

The equipment covered by these Specifications will be subject to inspection during manufacture and shall include for but not limited to major items of equipment such as lighting columns, luminaires, control gears, feeder pillars, etc.

A. The Contractor shall appoint a Third Party Inspector who is on the Ministry of Electricity and Water's approved list of Third Party Inspectors and he must obtain MEW's prior approval for appointing such an inspector. The Contractor shall bear all costs for inspection works including the Inspector's charges and shall provide all necessary facilities for the Inspector who may carry out or witness any tests that may be deemed necessary including representation, travelling, and transportation for factory tests.

B. The Contractor shall provide all necessary facilities for the Inspector who may carry out or witness any tests that may be deemed necessary including representation, travelling, and transportation for factory tests. All required materials for the inspection and testing as well as all testing equipment shall be supplied by the Contractor and included in the Contract price.

C. The Contractor shall carry out all tests specified in the latest relevant IEC/BS specifications. These shall be carried out to the satisfaction of and in the presence of the Inspector.

D. Shipment of materials and equipment shall not be effected unless the Inspector's release note is obtained. No release note issued by the Inspector shall relieve the Contractor from his liability to supply equipment or exonerate him from any of his guarantees according to these Specifications and the accepted submittals.

E. The Inspector in all cases shall compile the test/measurement results and readings in the English language only and submit same to the Ministry of Electricity and Water in two (2) complete sets of hard and soft copies for scrutiny, acceptance and record purposes.

13. CONCRETE FOUNDATIONS OF LIGHTING COLUMNS:

The concrete foundation of all lighting columns shall be class K-300 and all as shown in the latest revision of the MEW Drawing No. N//1/168.

A. The foundations for all lighting columns shall be cast in situ and the excavation for the cylindrical foundations shall be made by drilling with an auger of the same diameter as the foundations.

B. The top of the concrete foundation shall be flush with the finished and tiled pavement of the median and the side-walk. The foundations shall be free from all cracks or voids and shall have a fully aesthetic finishing in all respects. Only potable water shall be used for all concretes.

C. All lighting columns after erection and before any grouting is performed shall be vertically aligned. The Subcontractor shall have in his possession two theodolites for this purpose, which he shall simultaneously employ to have bearings from two right-angled directions while correcting the vertical alignment of the columns. The Ministry of Electricity & Water reserves the right to reject part or whole of the installation in case lighting columns are not aligned properly.

14. Installation of underground cables in upvc cable ducts and provision of concrete handholes:

All street lighting cables under new lighting systems shall be installed underground in 75 mm. diameter UPVC cable ducts having minimum wall thickness of 2.6 mm. at a depth of 75 cm. all as shown in the latest revision of the MEW Drawing No. N/1/168.

A. The cables shall be continuous between lighting columns without any joint and concrete handholes shall be provided at all bendings of the UPVC ducts, at both sides of all the road crossings, at the base of all lighting columns and also between all spans of ducts having lengths 60 metres and above, in order to facilitate drawing of the cables through the ducts. Where the curves are gradual, radius pipes however, can be installed with the approval of the Engineer only. The radius of curvature of any duct shall be minimum 10 metres.

B. Minimum 2 Nos. of UPVC cable ducts shall be provided all through between the handholes, of which one will remain as a spare duct. Additional cable ducts shall be provided whenever the runs of cables are more than two (for 3x35+2x16 sq.mm. cables) and more than three (for 2x16+1x10 sq.mm. cables), and the spare duct shall not be used for this. The ducts shall be encased at the joints by one (1) metre of concrete mixture. The concreteblocks shall be cast-in-situ and shall have an envelope of minimum 10 cms. at the top and bottom and 7.5 cms. on the two sides.

C. The Electrical Contractor shall submit for approval of the Engineer cable duct and handhole layouts for the entire street lighting systems with all necessary details and no works shall be started at site until and unless the Engineer's approval is gained on the same.

D. The overall dimensions of the handholes shall be 830 mm (L) x 680 mm (W) x 950 mm (D) with a clear opening of 600 mm x 450 mm. The handholes shall be pre-cast from Class K-300 concrete and frames and covers shall be from Polymer Matrix Composite materials. The frames shall have minimum 4 Nos. of suitably sized robust anchors for anchoring with the concrete. The casting of the handholes shall be performed together with the frame at one time and separate fixing of the frame at site will not be accepted.

E. The Polymer Matrix Composite frames and covers shall be medium duty type, able to

carry a load of minimum 180 KN and must withstand Kuwait's maximum temperature under the open sun, which reaches up to a maximum of 84^{o}C.

F. The covers of the handholes shall be firmly fixed to the frame with substantial stainless screws at opposite corners, provided with necessary slots with lifting handles and shall be engraved with letters "MEW-SL" of minimum 5 cm. height and 5 mm. deep. The covers shall also be embedded with a suitably sized metal piece at the centre position in order that the handholes can be easily located in case buried under the sand.

G. The manufacturer shall guarantee the Polymer Matrix Composite frames and covers for a period of minimum ten (10) years against any defect and discoloration.

H. The Electrical Contractor shall submit sample of reinforcement steel form for the handhole along with a sample of complete handhole with Polymer Matrix Composite frames and covers for the Engineer's approval. No works shall be started at site until and unless the Engineer's approval is gained on the samples. The handholes shall be installed with their tops aligned with the finished pavements. However, for unfinished ground levels, the top of the handholes shall be at 10 cm from the ground level and/or as approved by the Engineer. A length of 1.0 metre spare cable loop shall be provided at each handhole.

I. The UPVC ducts shall comply with the requirements of the BS:3506 (or equivalent international standard), Class 'C'. The ducts shall be inert, corrosion resistant and unaffected by water, oxidizing agents, aggressive soils, sand, fungal, growth, bacterial and electrolytic action. The ducts shall not ignite or support their own combustion.

J. The ducts shall be supplied in 6 metre length and shall be joined with an approved cement solvent conforming to BS:4346 or equivalent international standard. The UPVC ducts shall not be left exposed to ultra-violet light under the direct sun in the storeyard or inside the trench for more than seven (7) days without protection.

L. All the works of excavation of trench, laying of cable ducts, casting and installation of handholes, earth-pits, etc. shall be inspected by the Engineer before the cables and wires are permanently trained in the cable ducts, handholes, earth-pits or lighting units.

M. The Electrical Contractor shall pressure test approx. 10% of the UPVC cable ducts installed between handholes with air or water at a pressure equivalent to a head of 10 m. of water using an internationally recommend test method and equipment. The pressure must be contained without measurable loss for a period of at least 10 minutes after the pressurizing unit is shout off.

N. If the cable ducts fail to pass the above stipulated pressure tests, the Electrical Contractor shall repair or replace the ducts as directed and instructed by the Engineer at his own cost.

15. GROUNDING SYSTEMS:

15.1 EARTH ELECTRODE:

The earth electrode shown at the last column of a lighting circuit is indicative only and a copper clad earth electrode of 19 mm. diameter and 3.00 metre long shall be installed and connected at each lighting column and feeder pillar. The hand hole at the base of the lighting column shall also be used as an earth-pit and a separate earth pit is not required except for the feeder pillars.

The earth electrode shall be manufactured and tested in full compliance with the requirements of BS EN 50164-2:2008 and complete type test reports and certificates shall be submitted from an independent test laboratory (ASTA, KEMA or CESI). The radial copper coating shall be minimum 250 microns with 99.9% copper content. The earth electrode must be approved by the Ministry of Electricity & Water.

15.2 EARTH BONDING AND JUMPERS:

The lighting columns and the feeder pillars shall be connected to the earth electrodes respectively by 16 and 35 sq. mm. bare copper conductors and all connections shall be properly soldered and greased in an approved manner. The bonding between the control gear panels, cut-outs, etc. shall be by 16 sq. mm. Green or Green/Yellow coloured PVC insulated wires for lighting columns of 16 metres height and above and by 10 sq.mm wires for 12 metres height and less.

15.3 MEASUREMENT OF EARTH RESISTANCE FOR GROUNDING SYSTEMS:

The Resistance to Earth for the Grounding Systems shall not exceed 0.5 Ohm. The Subcontractor shall test and prove this for all grounding systems and drive additional rods if necessary and/or adopt other approved means recommended by international authorities to achieve the low resistance, at no extra cost whatsoever. All test equipment required shall be provided by the Subcontractor and the tests shall be carried out at the presence of the MEW Engineer.

A. The bill of quantities does not include any additional quantities of earth electrodes required to achieve the low earth resistance but the Contractor shall provide for these as part of the contract works.

16. ROAD CROSSINGS:

Wherever street lighting cables to columns and L.T. cables for supplying power to the Feeder Pillars cross asphalted carriage way or concrete pavement, the Subcontractor shall provide 2 way 10 cm. dia. UPVC ducts for street lighting cables and 2 way 15 cm.

, dia. duct for L.T. cables at each crossing, whether such ducts are specifically shown on the drawings or not.

A. The ducts shall be fully encased in Class-K140 concrete and shall be laid at a depth of 75 cms. and 1.0 metre respectively from the finished side-walk level. The widths and depths of the concrete encasements shall be respectively 470 mms. X 310 mms. and 570 mms. x 360 mms. for the street lighting and LT cables crossings.

B. The bill of quantities does not include any quantities of these Road Crossing Ducts but the Contractor shall provide for these as part of the contract works.

17. CONCRETE FOUNDATION OF FEEDER PILLARS**:**

The concrete foundations of all street lighting feeder pillars shall be class-K300 and closed type with 150 mm and 75 mm dia. UPVC sleeves for incoming and outgoing cables respectively, along with a manhole to facilitate drawing of cables through the UPVC pipes, all as shown in the latest revision of the MEW Drg. No. N/1/170.

A. The overall dimensions of the concrete foundation shall be 1.60M. (H) x 1.10 m. (W) x 0.60 M. (D) and the top of the concrete foundation shall be at 50 cm. from the finished ground level and the sides of the foundation shall be grouted and sloped after erecting the feeder pillar on it.

B. The overall dimensions of the manhole shall be 1000 mm. (L) x 1000 mm. (W) x 1200 mm. (D) with a clear opening of 700 mm x 700 mm. The manhole shall be pre-cast from Class K-300 concrete and frame and cover shall be from Polymer Matrix Composite materials. The frame shall have minimum 4 Nos. of suitably sized robust anchors for anchoring with the concrete. The casting of the manhole shall be performed together with the frame at one time and separate fixing of the frame at site will not be accepted.

C. The Polymer Matrix Composite frame and cover shall be medium duty type, able to carry a load of minimum 180 KN and must withstand Kuwait's maximum temperature under the open sun, which reaches up to a maximum of $84^{o}C$.

D. The covers of the handholes shall be firmly fixed to the frame with substantial stainless screws at opposite corners, provided with necessary slots with lifting handles and shall be engraved with letters "MEW-SL" of minimum 5 cm. height and 5 mm. deep. The cover shall also be embedded with a suitably sized metal piece at the centre position in order that the manhole can be easily located in case buried under the sand.

E. The manufacturer shall guarantee the Polymer Matrix Composite frame and cover for a period of minimum ten (10) years against any defect and discoloration.

F. The manholes shall be installed with their tops aligned with the finished

pavements. However, for unfinished ground levels, the top of the manholes shall be at 10 cm from the ground level and/or as directed by the Engineer. A length of 1.0 metre spare cable loop shall be provided at each manhole.

G. The Electrical Contractor shall submit samples of reinforcement steel forms for the feeder pillar foundation and the manhole along with a sample of complete manhole with Polymer Matrix Composite frame and cover for the Engineer's approval. No works shall be started at site until and unless the Engineer's approval is gained on the samples.

H. The manhole for the feeder pillars shall not be used as an earth-pit and a separate 500mm (L) x 500 mm (W) x 650 mm (D) earth pit with Polymer Matrix Composite frame and cover shall be provided for all feeder pillars for earthing purposes. Hot dip galvanized angles as specified above for the manhole shall be provided for the earth pits and a sample of complete earth-pit must be submitted by the Electrical Contractor for approval.

18. PROTECTIVE BARRIER AROUND THE FEEDER PILLAR:

The feeder pillars shall be provided with a protective barrier of steel bollards around them for safety and security reasons.

A. The bollards shall be app. 1.0 metre away from all sides of the feeder pillar and 75 mm. dia. galv. steel tubes having a wall thickness of minimum 3.5 mm. and height, 1.2 metres shall be used for this purpose. The Bollards shall be planted 50 cm. in 300 mm. x 300 mm. Class K-250 concrete foundation at about 50 to 60 cm. spacing, all as shown in the MEW Drawing No. N/1/170.

B. The bollards shall be filled in with Class-K140 concrete mixture and a base plate of 100 mm. x 100 mm. x 5 mm. thick sheet steel shall be welded at the bottom for anchoring purposes.

C. The bollards shall be painted Black and Yellow with reflectorized traffic paint after a primer and an intermediate white coat. All painting works shall be performed only after the surface of the bollards have been thoroughly cleaned of all dirts, rusts, weld sludges, oil, grease, etc.

D. The Subcontractor shall submit a detailed design of the protective barrier for the approval of the Engineer.

E. The bill of quantities does not include any protective barrier as a separate item and this shall be included with the prices of supply and erection of the feeder pillar.

19. REQUIREMENTS FOR CONCRETE WORKS:

19.1 CURING:

All concrete works of lighting column and feeder pillar foundations, pre-cast manholes and handholes and other miscellaneous concrete works of the project shall be adequately cured with potable water only. All concrete works shall be covered with thick canvas clothes and curing shall be performed two times a day as a minimum, once in the early morning and once in the evening or as directed by the Engineer. The Subcontractor shall make available necessary water tankers at the site for this purpose

19.2 TESTING OF CONCRETE:

The Subcontractor shall make all arrangement with the Ministry of Public Works for carrying out the necessary tests on the concrete in their Laboratory at his own cost. He shall follow the Site Engineer's instructions in this regard and carry out such tests at his entire satisfaction.

19.3 PROTECTIVE PAINTING OF CONCRETE:

The Subcontractor shall apply rubberized bitumen to the buried surfaces of all pre- cast concrete works like, manholes, handholes, earth-pits, etc. as a protective painting. The rubber bitumen emulsion shall be water bound emulsion with a minimum 60% total solid content by volume, comprising bitumen with fine particles of rubber. Not less than 10% nor more than 20% of the total solids shall be rubber. The consistency shall be such that it can be applied to the surface by brush at normal temperature. The Subcontractor shall submit material specifications and samples of rubber bitumen for Engineer's approval.

All concrete surfaces shall be cleaned before applying the rubberized bitumen. The priming coat shall be made by mixing 0.23 Kg. of approved powder or equivalent liquid detergent with 45 litres of clean water and adding this to 4.5 litres of emulsion. The priming coat shall be applied at the approximate rate of 9 litres per 30 sq.mm. The second coat of undiluted emulsion shall be applied at the rate of 9 litres per 15 sq.m as soon as the priming coat is dry.

20. COMPACTION OF AREAS AROUND CONCRETE FOUNDATIONS OF LIGHTING COLUMNS & FEEDER PILLARS AND CABLE TRENCHES:

All areas around the concrete foundations of lighting columns and feeder pillars as well as all cable trenches shall be compacted in layers of 20 cms. during back-filling to 95% (Ninety Five percent) as determined by the AASHTO-T180. The Subcontractor shall be ready to carry out sample laboratory tests to prove the grade of compaction specified if

so asked by the Engineer, at no extra cost whatsoever.

21. NUMBERING OF LIGHTING COLUMNS AND FEEDER PILLARS:

All street lighting columns shall be provided with identification number plates as specified herein and as approved by the Engineer.

A. The identification number plates shall be of two different sizes. The number plates for 10 metre height lighting columns and above shall be 500 mm (L) x 160 mm. (W) and the same for 8 & 6 metre columns shall be 400 mm. (H) x150 mm. (W).

B. The number plates shall be fabricated from minimum 2 mm. thick. Aluminium sheets and shall be rounded at the top and bottom. The front face shall be painted in black and shall have 10 mm. wide black borders all around. The back side of the plates shall be painted in smooth beige colour. All painting shall be by dry powder painting method.

C. The identification numbers shall be punched on high quality White Reflective Stickers from USA, Europe or Japan.

D. The height of the identification numbers shall be 12 cms. for all lighting columns of 10 M. height and above and the same for the lighting columns of 8 & 6 metre height shall be 7.5 cms.

E. The number plates shall be fixed on to the lighting columns at a height of 2.5 metres by two (2) Nos. of substantial stainless steel band type clamps.

F. Two (2) Nos. of identification number plates shall be provided for the lighting columns located at the medians in order to read the same from either side of the carriageway.

G. The workmanship of the number plates shall be of the highest order, or else, all plates will be rejected.

H. The number plate samples must be approved by the Ministry of Electricity & Water.

I. The Contractor is to submit a guarantee for three (3) years stating that the white reflective stickers will not be deformed and/or get damaged at Kuwait's extreme weather and temperature conditions and in case of any deformity and damage all identification number plates will be replaced and re-installed free of charge.

J. The numbering of lighting columns shall include Column No., Circuit No. and the Feeder Pillar No., in an order shown below or as directed by the Engineer.

- **COLUMN NO. 1**
- **CIRCUIT NO. e.g., 1**
- **F.P. NO. 1**

K. All street lighting feeder pillars shall be numbered with black coloured, non-removable and best quality Stickers or Spray Paints to a position as directed and approved by the Engineer.

22. BILL OF QUANTITIES:

The Bill of Quantities attached with this specification is without much details and include for the major items alone. The various items in the bill shall include the following:

22.1 10 Metre, Double Arm and Single Arm Lighting Columns with Cut-off Luminaires

One unit shall include:

- Concrete foundation as specified.
- 10 M. galvanized steel lighting columns with double or single arm bracket.
- Cut-off luminaire with 250 watt HPS Lamp,
- (2 Nos. for D.A units and 1 No. for S.A. units)
- Cut-out, 6 Amps
- Control gear panel with dual power dimming ballast, power factor improvement capacitor and associated power switch as specified and required.
- Connections between cut-out control gear panel and luminaire by means flexible cables as specified.
- Underground cables to columns as specified including excavation, laying of UPVC ducts, installing handholes and earth electrode device, back- filling, compacting/levelling and connecting.
- Identification numbering plate for lighting column as specified.
- All other accessories required.

22.2 Street Lighting Feeder Pillars:

One unit shall include:

- Concrete foundation as specified.
- New feeder pillar Type-E with astronomical time switch as specified.
- Connecting supply and out-going cables.
- Protective barrier as specified.
- Numbering of Feeder Pillar as specified.
- All other accessories required.

23. SUBCONTRACTOR:

The street lighting works shall be carried by a company who is registered in the MEW' list of approved Subcontractors and who has previously carried out street lighting works.

A. The main contractor shall propose and obtain the written approval of the MEW for his Electrical Subcontractor WITHIN MAXIMUM ONE MONTH from the date of award of the Contract.

B. The Electrical Subcontractor must have an Electrical Engineer and an Electrical Supervisor for ensuring proper supervision of the work. The Electrical Engineer shall have a degree of Bachelor of Science (B.Sc.) in Electrical Engineering and shall possess a minimum five (5) years of practical experience in total out of which two (2) years must be acquired in the field of street lighting works.

C. The Electrical Supervisor shall have a 3-years Polytechnical Diploma in Electrical Engineering and minimum Eight (8) years practical experience in the field of street lighting works. All Technicians shall be High School graduates and shall have minimum five (5) years of experience in the related field.

D. The Electrical Engineer shall be available at site periodically and during the times agreed to with MEW Engineer. The Electrical Supervisor shall be available at site during working hours.

E. The Electrical Subcontractor shall obtain approval of all his staff before starting any work at site.

24. WORK PROGRAMME:

The Electrical Subcontractor shall submit detailed work programme for approval by the MEW Engineer. Subsequently, updated work schedules in triplicate shall be submitted to the Engineer monthly, with the percentage of work completion marked on the same.

25. AS-BUILT DRAWINGS:

As-built drawings shall be prepared with AutoCAD and shall be fully suitable for CAD to GIS migration as stipulated in Cl.29 "Spatial Information Submittals Policy for Ease of Conversion of CAD Files into GIS Data Format" of this specification. The drawings shall be submitted as indicated in the Standard Specifications (One mother print of diaze polyester film and three white paper prints) to the same scale as the working drawings. The Subcontractor shall also submit the drawings in three (3) sets of Compact Discs.

A. The Subcontractor shall maintain a continuous record of all the field deviations from the working drawings, if any, as approved by the Engineer and shall incorporate these into the as-built drawings. The locations of all handholes, road crossing ducts, routing of cables/cable ducts, their distance from thekerbsides as well as feeding details of the feeder pillars, like Sub-station No., LT feeder, etc. shall be all clearly indicated on the drawings.

B. The drawings of all major items of equipment shall also be provided together with a schedule detailing make, type rating etc. of all the equipment and components therein. The Subcontractor shall also provide as-built drawings to scale 1:2000 when asked by the MEW Engineer.

26. SPATIAL INFORMATION SUBMITTALS POLICY FOR EASE OF CONVERSION OF CAD FILES INTO GIS DATA FORMAT:

The Electrical Contractor must adhere to the following when submitting as-built street and external lighting layout drawings to the Ministry of Electricity & Water.

A. The contractor shall obtain the latest CAD Drawings Submittal Guidelines document from MEW.

B. The contractor shall obtain the latest (most updated) Kuwait Base Map used at MEW, to be used as the Key Map of all as-built street and external lighting layout drawings.

C. The contractor shall accompany the as-built street and external lighting layout drawings with spatial and attribute information in digital format according to the standards described in the Guidelines. The digital format shall be in Write- Once media (DVD or CD).

D. The contractor shall make use of the latest MEW StreetLightingCADTemplate (template for the Street Lighting Network) and ElecDistCADTemplate (template for the Electrical Distribution Network) drawings, described in the Guidelines document, as the basis of all network drawings.

E. The contractor shall ensure that any submitted as-built street and external lighting layout drawings contain a Key Map and properly measured dimensions from the road centre line or edge of a parcel.

F. The contractor shall use the following Spatial Reference as the projection system for all spatial information:

- Kuwait Utility Data Management System (KUDAMS) Datum, Kuwait Traverse Mercator KTM, GRS 1980.

G. The contractor shall submit all data structured according to MEW's Data Models described in the Guidelines document that are in accordance with the industry standard data models, including:

- MEW Electrical Distribution Physical Data Model for Electrical Distribution Networks.

H. The contractor shall ensure that physical connectivity of the electrical assets is upheld and shall model all edge-junction related rules, described in the Guidelines document, in the submitted drawings.

I. The contractor shall adhere to the following general AutoCAD Standard Guidelines, which are elaborated further in the Guidelines document:

- Create Objects with Consistent Geometry
- Do Not Create Symbols using Cross Lines, Cross Lines and Circle combinations.
- Snap Lines at their Intersection
- Create Polygons using Closed Polylines only
- Create and Save Attributes in the CAD Drawing File Using the Corresponding "XDataElectric" Tool

J. MEW shall verify the compliance, completeness, and accuracy of the submitted information. The contractor shall make all necessary modifications to achieve compliance with MEW Standard.

K. The acceptance of the work executed by the contractor shall not be considered complete until all information is submitted and approved by MEW.

27. Inventory information on computer diskettes:

The Subcontractor shall prepare a complete and fully detailed inventory of each every item of street lighting equipment, accessories etc. employed for the lighting installation of the project and provide this information on computer diskettes in three (3) complete sets.

28. MAINTENANCE OF NEW STREET LIGHTING INSTALLATION:

The Electrical Subcontractor shall maintain the entire new lighting installations under the contract for a period of TWO (2) COMPLETE YEARS AS A WARRANTY TO HIS WORKS from the date of completion of the project.

A. The Electrical Subcontractor shall carry out day and night maintenance and survey patrol on **fortnightly basis** and hence, provide one patrol vehicle with driver, one electrician and basket crane and other vehicles as and when necessary for this purpose throughout the maintenance period of the contract.

B. The Subcontractor shall carry out all repair works including attending to and rectifying all faults and damage, howsoever they be caused and shall be responsible for the replacement of all wear and tear items of all equipment. Any parts, accessories, cables, controlgears, feeder pillars, lamps, fuses etc., which have been put out of service or otherwise damaged due to the contractor's negligence or which have failed or become defective due to material or manufacturing faults shall be rectified and/or replaced by the contractor at no extra cost whatsoever.

C. The Electrical Subcontractor shall dismantle and transport to the Employer's store any accidented lighting column and collect from the store and erect replacement lighting column complete with all accessories as directed by the Engineer, all at his own expense.

D. The maintenance works will be supervised by and will be under the full control of the Ministry of Electricity & Water and in case of failure on the part of the Contractor to carry out any maintenance work in a proper manner and on time, penalties will be imposed in accordance with the terms and conditions s ti pulate d in the Minis try' s Mainten anc e C o ntrac t Spec if ic ati ons for different Governorates.

E. The Bill of Quantity does not include the maintenance works as a separate item but the Electrical Subcontractor shall provide for these as a part of the contract works.

29. FINAL ACCEPTANCE INSPECTION**:**

The final acceptance inspection will be carried out and a certificate will be issued to the Subcontractor at the end of the warranty period only when the Subcontractor's obligations are all fulfilled to the entire satisfaction of the Ministry of Electricity and Water Engineer.

30. PENALTIES & VIOLATIONS:

A. In the event of absence of the Electrical Subcontractor's engineer or supervisor, KD.100/- (Kuwaiti Dinars one hundred only) shall be deducted per each day of absence. In the event of absence or delay of any of the required manpower mentioned in the schedule of manpower approved by the Ministry, the daily wage shall be deducted according to the daily wages of the manpower stated in the schedule.

B. In the event where the Subcontractor does not provide a first aid kit to any of the teams, an amount of KD.100/- (Kuwaiti Dinars one hundred only) shall be deducted from the Subcontractor's entitlements. The penalty shall be doubled in the event of repetition.

C. In the event of leaving waste at the work site after completion of the installations works, an amount of KD. 100/- (Kuwaiti Dinars one hundred only) shall be deducted from the Subcontractor's entitlements. The penalty shall be doubled in the event of repetition.

D. In the event where it was proved that the Subcontractor used manual compactors to compact the soil at any site, the Ministry shall have the right to deduct KD.100/- (Kuwaiti Dinars one hundred only) from the Subcontractor's entitlements. The penalty shall be doubled in the event of repetition.

E. In the event where the Subcontractor appoint any manpower for the completion of the contract works, not approved by the Ministry, these manpower shall be registered in the file of manpower as rejected by the Ministry, with the deduction of KD.100/- (Kuwaiti Dinars one hundred only) from the Subcontractor's entitlements. The penalty shall be doubled in the event of repetition.

F. In the event where the Subcontractor does not provide a Signboard mentioning the contract particulars, KD.100/- (Kuwaiti Dinars one hundred) shall be deducted from the Subcontractor's entitlements. The penalty shall be doubled in the event of repetition.

G. In the event where the Subcontractor does not provide a communication means for the Contract's engineer or supervisor daily throughout the validity period

of the contract, KD.20/- (Kuwaiti Dinars twenty only) shall be deducted from the Subcontractor's entitlements per day and per one means. The penalty shall be doubled in the event of repetition.

H. In the event of replacement, dismissal or resignation of any of the employees concerned by the Contract, or they take leaves without notifying the Ministry of Electricity and Water officially and without obtaining the approval of the Ministry's supervising engineer, the wage of the concerned person shall be deducted from the Subcontractor's entitlements until approval of the substitute.

I. In the event where it was proved that the Contract's engineer or supervisor works on any other contract, the concerned person shall be rejected from the Contract's works, deducting his wage of 6 months from the Subcontractor's entitlements according to the schedule of manpower.

J. In the event where the Subcontractor uses invalid cars and vans or the same are not conformant to that required for the performance of the installations works, the Ministry shall have the right to reject these teams (until replacement of the vehicles as required). This shall also be applied in the event of not placing a sticker indicating the name of the company and the number of the contract on such vehicles, deducting KD.50/- (Kuwaiti Dinars fifty only) from the Subcontractor's entitlements per each case. The penalty shall be doubled in the event of repetition.

K. In the event where any worker of the installation teams do not wear the uniform provided by the Subcontractor, his daily wage shall be deducted according to the schedule of manpower. The penalty shall be doubled in the event of repetition.

L. In the event where the installation works do not start on the time agreed upon with the Ministry's Engineer, an amount of KD.100/- (Kuwaiti Dinars one hundred only) shall be deducted. The penalty shall be doubled in the event of repetition.

M. In the event where it was noticed that on performing the installation works of the columns, the Subcontractor leaves a lighting column without completion of internal grounding, or leaves a lighting column with loose wires (control gears, cut-outs), KD.100/- (Kuwaiti Dinars one hundred only) shall be deducted from the Subcontractor's entitlements. The penalty shall be doubled in the event of repetition.

N. In the event where the Subcontractor does not cure or use canvas in case of casting new concrete foundations as specified, an amount of KD.500/- (Kuwaiti Dinars five hundred only) shall be deducted from the Subcontractor's entitlements. The penalty shall be doubled in the event of repetition.

Note: (The type of canvas, method of fixing and times of curing with water shall be according to the instructions of the Ministry's engineer).

O. In the event of fixing any internal parts of the feeder pillars or lighting columns with

tools other than those specified there for, an amount of KD.100/- (Kuwaiti Dinars one hundred only) shall be deducted from the Subcontractor's entitlements. The penalty shall be doubled in the event of repetition.

P. In the event of accumulation of waste and trash near and under the site offices of the company or in the event of non-observation of cleanliness, an amount of KD.100/- (Kuwaiti Dinars one hundred only) shall be deducted from the Subcontractor's entitlements. The penalty shall be doubled in the event of repetition.

Q. In the event where it was proved that the Contract's engineer or supervisor does not operate the mobile phones or does not respond to the calls of the Ministry's employees without prior excuse and convincing reason, the daily wage of the concerned person shall be deducted according to the schedule of manpower. In the event of repetition, he shall be subject to interrogation.

35. LED LIGHT FITTINGS

All light fittings shall be of first class quality made by reputable International manufacturer and have ISO 9001 certification from the standard range of production and illustrated in their catalogues and suitable in all respects for trouble free operation in 240 Volts 50 HZ. Light fitting shall be used in Kuwait for a minimum period of 10 year in Ministry project.

35.1 General requirement for all LED light fittings:

a) All LED light fittings shall comply to safety standards: EN 60598, EN 61195, EN 61347, EN 62031, Test certificate from Third Party similar to IEC or KEMA or equal approved shall be provided with offer.

b) Manufacturers have to prove that the LEDs used in LED light fittings are from the same family. No tolerance in colour temperature change will be allowed after installation.

c) All LED light fittings must have an approved agent in Kuwait have ISO 9001 and engineering specialist staff in lighting.

d) IES (Illuminating Engineering Society) LM-80 Estimated end life of LED test report and IES (Illuminating Engineering Society) LM-79 Photometric Test report. These tests report shall be provided for each LED Light Fitting.

e) The Maximum allowed depreciation for 50,000 hours is 20% to 30% as mentioned in technical requirement for each luminaire. Lumen depreciation curve shall be submitted with offer.

f) All LED light fitting shall be provided by one International manufacturer similar to PHILIPS, OSRAM, THORN, SYLVANIA, TRILUX, SITECO, WILA (GERMANY), HUBBELL – USA, GENERAL ELECTRIC USA, and equal approved international manufacturers shall be globally recognized to bring sustainability and shall be reflected on global rankings like Dow jones Sustainability Index and Carbon Disclosure Project. and shall be from US, JAPAN and WEST EUROPE.

g) Dali dimmer system and lighting management system shall be supplied by manufacturer of LED light fittings.

h) Inspection of manufacturer's place of LED light fittings shall be provided for 2 Nos. (Two) MEW engineer, one from technical Services and One from Water Department. All necessary cost for accommodation at least for one week, transportation, air ticket, should borne by contractor.

i) The LED light fitting system warranty should be for 5 years (system include but not limited to LEDs chips, modules, wiring, driver, connectors, terminal blocks, hardware, glass, bolts, anchors, washers, electronic devices). The warranty shall be a writeen warranty from both the supplier and the agent including replacement of defetcted units at site.

Applicable Standards:

The following documents (or equivalent International approved standards shall be followed:

a) IESNA (Illuminating Engineering Society of North America) - **Lighting Handbook 10th Edition.**

b) IESNA **TM-16 -05** Technical Memorandum on Light Emitting Diode (LED) Sources & Systems.

c) IES/IESNA **LM-79-08** Approved Method: Electrical and Photometric Measurements of Solid-State Lighting Products.

d) IES/IESNA **LM-80-08** Approved Method for Measuring Lumen Maintenance of LED Light Sources.

e) **ANSI/NEMA/ANSLG C78.377-2008**-Americian National Standard for Chromatically of Solid State Lighting Products.

F) **BS EN 62471:2008** or ANSI/IESNA **RP-27.3-07** Photobiological Safety of Lamps and Lamp Systems.

g) International Commission on Illumination (**CIE**).

h) Joint Electron Device Engineering Council (**JEDEC**).

i) **ANSI C82.77-2002** - Harmonic Emission Limits & **IEEE Std. 519** 1992 - Harmonic Limits.

Thermal Management:

The LED modules shall be mounted on heavy duty heat sinks (with extruded or die cast Aluminum with less copper content is acceptable) to ensure excellent heat dissipation.

The design of the heat sinks shall be such that there is a direct thermal path from the led junctions to the atmosphere thus providing a thermal transfer effect throughout the life of the luminaire. The heat sinks shall be proprietary and designed by the lighting manufacturer to enable the luminaires to work efficiently in Kuwait climatic conditions. The luminaire shall be provided with a demonstrated ventilation arrangement allowing heat to be dissipated to the atmosphere. The luminaire shall be designed to prevent collection of debris on the heat sinks by proven and stated means.

A Heat sink simulation is needed to demonstrate the ability of the housing to release heat generated by PCBs and effect on Tsp. during operation of 25-50° C ambient. A Thermal camera must be used to identify the hottest/lowest Tsp.

Technical Data:

For each type of lighting fixture, data on features, accessories, finishes and the following shall submit with offer including: -

1) Provide physical description of lighting fixture including dimensions.
2) Provide details of the driver(s) including, manufacturer, driver efficiency, catalogue code, certifications and input watts.
3) Provide luminaire photometric reports per IESNA LM-79-08, or similar International approved Equivalent.
4) Within LM-79-08 scope, it should show CCT, CRI, PF, Wattage, Driver Current, LPW, CCx and CCy.
5) Provide documentation of the expected useful life including the testing and calculation of useful life and verification of site lighting performance at that life. If the site defined performance methods are used, the interpolation between the three sets of LM-80 data.

LED Sources Technical Requirements:

Within the fixture the LED sources shall meet the following requirements:
Note. Attach separate supporting documents if required.

- Operating temperature rating shall be between -10°C and minimum +50°C at a minimum 90% Relative Humidity (RH).

- Correlated color temperature (CCT): 5000K (Nominal Values) within Macadam Ellipse steps and ANSI.
- Color rendering index (CRI): ≥ 70
- Luminaire manufacturer shall submit reliability reports indicating that the manufacturer of the LED (chip, diode, or package) has performed Joint Electron Devices Engineering Council (JEDEC), or similar International approved equivalent; reliability tests on the LEDs as follows:

- Factory prerelease test reports shall be provided from the LED manufacturer duly complying with JEDEC.

LED Drivers Technical Requirements –

Within the fixture the LED driver(s) shall meet the following requirements:

1) Driver/Fixture to have some means of built-in overheat thermal protection in the form of automatic dimming or stepping/holding down of the driver where temperature exceeds operational limits. Thermal cut-out devices which turn the fixture LEDs completely off are not acceptable.
2) The Driver and driver output current must be shown to be fully tested and compatible with the exact LED chips/engine of the luminaire.
    - All information provided and the cost analysis/payback calculations should be calculated with the exact drive current including the calculation for the life cycle, life and resultant increase or decrease of the energy consumption if applicable.
    - Input voltage; capable of 240V±10%, single phase or as required by the site.
3) Power supplies can be UL Class 1 or II output or similar European CE or International equivalent.
4) Surge protection: Must be tested in accordance to the requirements of IEEE/ASNI C62.41.2-2002, Scenario I Location Category C or International equivalent.
5) Drivers shall have a Power Factor (PF) of L: ≥ 0.90.
6) Drivers shall comply with FCC 47 cfr part 15 non-consumer RFI.EMI standards or equivalent.
7) Drivers shall be RoHS Compliant.
8) Drivers shall have a total individual luminaire Harmonic Distortion (THD) of: ≤ 20% in accordance with ANSI C82.77 (2002). However the Contractor shall measure the harmonic at the supply point (LV side of the distribution substation) after the installation of all the LED lights and adopt harmonic compensation methods to limit the total harmonics distortion in the supply voltage to maximum 5% as per IEEE 519 Regulations.

Luminaire Requirements:

The dedicated luminaire expected useful life (light output) based on Amb. temp. of 50° C.
Depreciation requirements would be useful by interpolation of LM-80 report, TM-21 (reported values) data as well as Luminaires. It is clear that the fitting must operate at 50 degree ambient temp.

Useful Life Time Calculations method:

Only In site performance test method would be accepted:

1- ISTMT reports @ 50°C. (Should be defined separately in case of different fittings sizes). Thermal camera shot should be used to indicate higher and lowest temperature point.
2- TM-21 reported (Not Calculated) should be shown for different Tsp run @ 10000hr
3- LM-80-2008 Test results.
4- Quadratic Interpolation curves to show up lumen Maintenance over 50K hr as well as defined Tsp as shown in ISTMT report, LM-80-2008 and TM-21 reported.
5- L70 (10k) 50000hr @ 50°C. ambient temp. (Reported life time).
6- LLD (Lumen Loss Depreciation) from 25:50°C.

Photobiological Safety:

The Manufacturer shall provide a written undertaking to the satisfaction of MEW of testing to the following standards:

Ensure luminaire complies with Photobiological Safety of lamps and lamp systems in accordance with the requirements of BS EN 62471:2008 or ANSI/IESNA RP-2 7.3 - 0. Provide proof of testing and compliance with the standards with certification provided to prove the fixture is classed as “Exempt” or Risk one. (The main target is to show up passed for blue rays toxic effect on retina).

List of test certificates shall submit with the Offer: -

1- LM-79-08 test reports run by internationally approved laboratory.
2- UL listing certificates. Or CE certificate of conformity
3- Photo biological test report
4- Thermal Management Test report (ISTMT) @ 50°C. Defining clearly Tsp and Driver current at designated ambient temp of 50°C.

5- Useful Life time calculations should include following (In site performance method):

a- ISTMT report

b- LM-80 report

c- TM-21 reported values (not calculated)

d- LLD values from 25:50°C.

e- Extrapolation curve and life time declaration on L-70.

Lighting Calculation

The contractor shall provide lighting calculation (point by point) for each part of the building (i.e.Office (500 lux as minimum), Corridor (300 lux as minimum), Stores (300 lux as minimum), etc.) taking into consideration maintain factor 0.7 and uniformity rate more than 0.6.

Light Fitting - Type A5/4/10/LED (with opal optic)

Sl.No.	Description	
1	Mounting type	Recessed mounted Luminaires
2	Dimension	Approximately 60 cm x 60 cm and shall be suitable for the type of false ceiling.
3	Housing	Housing made of sheet steel white finish powder coated and with micro louvre and opal PMMA (milky and non-transparant) covering.
4	Power consumption	35 W ~ 40 W
5	Luminous flux	3800 - 4000 Lumens
6	Colour temperature	4000K
7	Colour rendering index	CRI > 80
8	Dimmable	10 to 100% adjustment illumination level by (DALI) Digital Addressable Lighting Interface).
9	Optical system	With micro louvre for good glare reduction. Suitable for VDU workstations according to EN-12464-1 via limited luminance L ≤ 1500/cd/m² for beam angle above 65º all-round.
10	Protection class	IP 20

11	IK Code / Impact resistance	IK02/0.2J
12	Working temperature	-10 to 40°C
13	Estimated end life of LED test report.	As per IES (Illuminating Engineering Society) LM-80 (Estimated end of life of LED test report).
14	LED Service life	50,000 operating hours at L80 B10
15	Photometric Test Report	A per IES LM-79 (Photometric Test Report)
16	RoHS, Reach, IDA Complaint	YES
17	Guarantee	5 Years
18	Working voltage and frequency	Voltage 240 VAC / Frequency 50 Hz.
19	Power Factor	More than 0.90
20	Approved to	IEC 60969

Light Fitting - Type A5/4/10/E (with opal optic)

Sl.No.	Description	
1	Mounting type	Recessed mounted Luminaires
2	Dimension	Approximately 60 cm x 60 cm and shall be suitable for the type of false ceiling.
3	Housing	Housing made of sheet steel white finish powder coated and with micro louvre and opal PMMA (milky and non-transparant) covering.
4	Power consumption	35 W ~ 40 W
5	Luminous flux	3800 - 4000 Lumens
6	Colour temperature	4000K
7	Colour rendering index	CRI > 80
8	Dimmable	10 to 100% adjustment illumination level by (DALI) Digital Addressable Lighting Interface).
9	Optical system	With micro louvre for good glare reduction. Suitable for VDU workstations according to EN-12464-1 via limited luminance L ≤ 1500/cd/m² for beam angle above 65º all-round.

10	Protection class	IP 20
11	IK Code / Impact resistance	IK02/0.2J
12	Working temperature	-10 to 40°C
13	Estimated end life of LED test report.	As per IES (Illuminating Engineering Society) LM-80 (Estimated end of life of LED test report).
14	LED Service life	50,000 operating hours at L80 B10
15	Photometric Test Report	A per IES LM-79 (Photometric Test Report)
16	RoHS, Reach, IDA Complaint	YES
17	Guarantee	5 Years
18	Working voltage and frequency	Voltage 240 VAC / Frequency 50 Hz.
19	Power Factor	More than 0.90
20	Approved to	IEC 60969
21	Battery Kit	The light fitting provided with 3-hours battery kit.

Light Fitting - Type A5/4/10/LED (with Lens optic)

Sl.No.	Description	
1	Mounting type	Recessed mounted Luminaires
2	Dimension	Approximately 60 cm x 60 cm and shall be suitable for the type of false ceiling.
3	Housing	Housing made of sheet steel white finish powder coated with lens optic. Light guided via square lens optic perfect glare reduction and bat-wing light distribution.
4	Power consumption	35 W ~ 40 W
5	Luminous flux	3900 - 4500 Lumens
6	Colour temperature	4000 K
7	Glare control	Glare control to EN-12464-1 with L65<1,000 cd/m² at 65º in all directions

		and UGR< 16 for workstations.
8	Colour rendering index	CRI > 80
9	Dimmable	10 to 100% adjustment illumination level by (DALI) Digital Addressable Lighting Interface).
11	Protection class	IP 40
12	IK Code / Impact resistance	IK02/0.2J
13	Working temperature	-10 to 40°C
13	Estimated end life of LED test report.	As per IES (Illuminating Engineering Society) LM-80 (Estimated end of life of LED test report).
14	LED Service life	50,000 operating hours at L80 B10
15	Photometric Test Report	A per IES LM-79 (Photometric Test Report)
16	RoHS, Reach, IDA Complaint	YES
17	Guarantee	5 Years
18	Working voltage and frequency	Voltage 240 VAC / Frequency 50 Hz.
19	Power Factor	More than 0.90
20	Approved to	IEC 60969

Light Fitting - Type A5/4/10/E (with Lens optic)

Sl.No.	Description	
1	Mounting type	Recessed mounted Luminaires
2	Dimension	Approximately 60 cm x 60 cm and shall be suitable for the type of false ceiling.
3	Housing	Housing made of sheet steel white finish powder coated with lens optic. Light guided via square lens optic perfect glare reduction and bat-wing light distribution.
4	Power consumption	35 W ~ 40 W
5	Luminous flux	3900 - 4500 Lumens
6	Colour temperature	4000 K

7	Glare control	Glare control to EN-12464-1 with L65<1,000 cd/m² at 65º in all directions and UGR< 16 for DSE workstations.
8	Colour rendering index	CRI > 80
9	Dimmable	10 to 100% adjustment illumination level by (DALI) Digital Addressable Lighting Interface).
10	Protection class	IP 40
11	IK Code / Impact resistance	IK02/0.2J
12	Working temperature	-10 to 40°C
13	Estimated end life of LED test report.	As per IES (Illuminating Engineering Society) LM-80 (Estimated end of life of LED test report).
14	LED Service life	50,000 operating hours at L80 B10
15	Photometric Test Report	A per IES LM-79 (Photometric Test Report)
16	RoHS, Reach, IDA Complaint	YES
17	Guarantee	5 Years
18	Working voltage and frequency	Voltage 240 VAC / Frequency 50 Hz.
19	Power Factor	More than 0.90
20	Approved to	IEC 60969
21	Battery Kit	The light fitting provided with 3-hours battery kit.

Light Fitting - Type A3/2/20 (LED)

Sl.No.	Description	
1	Mounting type	Surface mounted LuminairesThe fitting shall be suitable for ceiling and wall mounting.
2	Dimension	Approximately 120 cm x 30 cm x 09cm
3	Housing	Housing made of sheet steel white finish powder coated and with opal PMMA covering.
4	Power consumption	35 W ~ 40 W

5	Luminous flux	3800 - 4000 Lumens
6	Colour temperature	4000K
7	Colour rendering index	CRI > 80
8	Dimmable	10 to 100% adjustment illumination level by (DALI) Digital Addressable Lighting Interface).
9	Protection class	IP 40
10	IK Code / Impact resistance	IK02/0.2J
11	Working temperature	-10 to 40°C
12	Estimated end life of LED test report.	As per IES (Illuminating Engineering Society) LM-80 (Estimated end of life of LED test report).
13	LED Service life	50,000 operating hours at L80 B10
14	Photometric Test Report	A per IES LM-79 (Photometric Test Report)
15	RoHS, Reach, IDA Complaint	YES
16	Guarantee	5 Years
17	Working voltage and frequency	Voltage 240 VAC / Frequency 50 Hz.
18	Power Factor	More than 0.90
19	Approved to	IEC 60969

Light Fitting - Type A3/2/20 (E)

Sl.No.	Description	
1	Mounting type	Surface mounted Luminaires
2	Dimension	Approximately 120 cm x 30 cm x 09cm
3	Housing	Housing made of sheet steel white finish powder coated and with opal PMMA covering.

4	Power consumption	35 W ~ 40 W
5	Luminous flux	3800 - 4000 Lumens
6	Colour temperature	4000K
7	Colour rendering index	CRI > 80
8	Dimmable	10 to 100% adjustment illumination level by (DALI) Digital Addressable Lighting Interface).
9	Protection class	IP 40
10	IK Code / Impact resistance	IK02/0.2J
11	Working temperature	-10 to 40°C
12	Estimated end life of LED test report.	As per IES (Illuminating Engineering Society) LM-80 (Estimated end of life of LED test report).
13	LED Service life	50,000 operating hours at L80 B10
14	Photometric Test Report	A per IES LM-79 (Photometric Test Report)
15	RoHS, Reach, IDA Complaint	YES
16	Guarantee	5 Years
17	Working voltage and frequency	Voltage 240 VAC / Frequency 50 Hz.
18	Power Factor	More than 0.90
19	Approved to	IEC 60969
20	Battery Kit	The light fitting provided with 3-hours battery kit.

Light Fitting - Type A7/1/20 (LED)

Sl.No.	Description	
1	Mounting type	Surface mounted LuminairesThe fitting shall be suitable for ceiling and wall mounting.

2	Dimension	Approximately 120 cm x 30 cm x 12cm.
3	Luminaire body	Luminaire body of polycarbonate flame-resistant and recyclable.
4	Power consumption	23 W ~ 25 W
5	Luminous flux	2300 - 2500 Lumens
6	Colour temperature	4000K
7	Colour rendering index	CRI > 80
9	Protection class	IP 66
10	IK Code / Impact resistance	IK08/0.8J
11	Working temperature	Shall be suitable to work outdoor at Kuwait weather condition.
12	Estimated end life of LED test report.	As per IES (Illuminating Engineering Society) LM-80 (Estimated end o life of LED test report).
13	LED Service life	50,000 operating hours at L80 B10
14	Photometric Test Report	A per IES LM-79 (Photometric Test Report)
15	RoHS, Reach, IDA Complaint	YES
16	Guarantee	5 Years
17	Working voltage and frequency	Voltage 240 VAC / Frequency 50 Hz.
18	Power Factor	More than 0.90
19	Approved to	IEC 60969

Light Fitting - Type A7/2/20 (LED)

Sl.No.	Description	
1	Mounting type	Surface mounted LuminairesThe fitting shall be suitable for ceiling and wall mounting.
2	Dimension	Approximately 120 cm x 40 cm x 12cm.
3	Luminaire body	Luminaire body of polycarbonate flame-resistant and recyclable.

4	Power consumption	35 W ~ 40 W
5	Luminous flux	2500 - 4000 Lumens
6	Colour temperature	4000K
7	Colour rendering index	CRI > 80
9	Protection class	IP 66
10	IK Code / Impact resistance	IK08/0.8J
11	Working temperature	Shall be suitable to work outdoor at Kuwait weather condition.
12	Estimated end life of LED test report.	As per IES (Illuminating Engineering Society) LM-80 (Estimated end o life of LED test report).
13	LED Service life	50,000 operating hours at L80 B10
14	Photometric Test Report	A per IES LM-79 (Photometric Test Report)
15	RoHS, Reach, IDA Complaint	YES
16	Guarantee	5 Years
17	Working voltage and frequency	Voltage 240 VAC / Frequency 50 Hz.
18	Power Factor	More than 0.90
19	Approved to	IEC 60969

Light Fitting - Type A7/2/20

Sl.No.	Description	
1	Mounting type	Surface mounted LuminairesThe fitting shall be suitable for ceiling and wall mounting.
2	Dimension	Approximately 120 cm x 40 cm x 14cm.
3	Housing	Housing made of sheet steel white finish powder coated and with opal PMMA covering.
4	Power consumption	35 W ~ 40 W
5	Luminous flux	3800 - 4000 Lumens

6	Colour temperature	4000K
7	Colour rendering index	CRI > 80
8	Dimmable	10 to 100% adjustment illumination level by (DALI) Digital Addressable Lighting Interface).
9	Protection class	IP 40
10	IK Code / Impact resistance	IK02/0.2J
11	Working temperature	-10 to 40°C
12	Estimated end life of LED test report.	As per IES (Illuminating Engineering Society) LM-80 (Estimated end of life of LED test report).
13	LED Service life	50,000 operating hours at L80 B10
14	Photometric Test Report	A per IES LM-79 (Photometric Test Report)
15	RoHS, Reach, IDA Complaint	YES
16	Guarantee	5 Years
17	Working voltage and frequency	Voltage 240 VAC / Frequency 50 Hz.
18	Power Factor	More than 0.90
19	Approved to	IEC 60969

LED Recessed / Down Light - Type (M)

IP Rating	IP 20
Power consumption	35 W ~ 40 W
Lumens	2500 Lm – 3000 LM as min.
Working voltage and frequency	Voltage 240 VAC / Frequency 50 Hz.
Life time	50,000 hours
Power factor	More than 0.9
Unified glare ratio	< 19

Colour rendering index	CRI > 80
Dimmable	10 to 100% adjustment illumination level by digital DALI (Digital Addressable Lighting Interface)
Colour temperature	4000k.
Reflector	Mirror reflector made of pure aluminium (A1 99.9) Silk matt, silver polished, Dust repellent and Fingerprint resistant.
Luminaries housing	Made of dye-cast aluminium
Guarantee	5 years
Approved to	IEC 60969
Energy efficiency rating	A

LED recessed / down Light – Type (S) (Adjustable Scoop Range)

IP Rating	IP 20
Power consumption	35 W ~ 40 W
Lumens	2000 Lm – 3000 LM as min.
Working voltage and frequency	Voltage 240 VAC / Frequency 50 Hz.
Life time	50,000 hours
Power factor	More than 0.9
Colour rendering index	CRI > 80
Colour temperature	3000 K. – 4000 K
Reflector	Mirror reflector made of pure aluminium (A1 99.9).
Luminaries housing	Made of dye-cast aluminium
Guarantee	5 years
Approved to	IEC 60969
Energy efficiency rating	A
Adjustable Tilting angle	35 Degree
Rotation angle	355

Attn: The exact location for Down light type 'S' shall be determined at site.

36.11 **LED Recessed / Down Light – Type (F)**

IP Rating	IP 20
Power consumption	40 W ~ 50 W
Lumens	4000 Lm – 4500 LM as min.
Working voltage and frequency	Voltage 240 VAC / Frequency 50 Hz.
Life time	50,000 hours
Power factor	More than 0.9
Unified glare ratio	< 19
Colour rendering index	CRI > 80
Dimmable	10 to 100% adjustment illumination level by digital DALI (Digital Addressable lighting interface)
Colour temperature	3000 K – 4000 K
Reflector	Mirror reflector made of pure aluminium (A1 99.9)
Luminaries housing	Made of dye-cast aluminium
Guarantee	5 years
Approved to	IEC 60969
Energy efficiency rating	A

LED Recessed / Down Light – Type (N)

IP Rating	IP 54
Power consumption	25 W ~ 30 W
Lumens	2000 LM - 2500 LM as min.
Working voltage and frequency	Voltage 240 VAC / Frequency 50 Hz.
Life time	50,000 hours
Power factor	More than 0.90
Colour rendering index	CRI > 80
Colour temperature	3000 k – 4000 K

Reflector	Mirror reflector made of pure aluminium (A1 99.9)
Luminaries housing	Made of dye-cast aluminium
Guarantee	5 years
Approved to	IEC 60969
Energy efficiency rating	A

36.13 HIGH BAY LED LIGHT FITTING TYPE (H) used in Explosive atmospheres of gas or vapour (Division 2 areas as defined in UL-844 Standard for lighting fixtures for hazardous locations, Class I, Division 2

Housing	- Ballast tank, splice box and cast guards corrosion resistant copper-free aluminium alloy. - Baked powder epoxy/polyester finish, electrostatically applied for complete, uniform corrosion protection. - All external hardware - stainless steel - Reflector - Aluminium
Diffuser	Tempered glass sealed with aluminium ring.
Power Consumption	Minimum 130 Watt, Maximum 150 Watt
Working Voltage	Voltage 240 VAC / Frequency 50 Hz.
Luminous efficiency	More than 91 LM/W as minimum.
Compliances	- UL-8750 for LED lighting - UL 844 Standard for Lighting fixtures for hazardous locations Class 1, Division 2; Class II, Division 1 and 2, Class III.
Colour temperature	5000 – 4000
Life time	50,000 hours
Guarantee	5 years
Working temperature	-10 to + 55°C as minimum.
Protection degree	IP66 as minimum.
Certifications	CE, RoHS, UL, LM79-08 Certified “Absolute” Photometry, including Chromaticity colour for Solid State Lighting.
Power Factor	More than 0.90
Total Harmonic Distortion (THD)	Less than 15%
Colour Rendering Index (C.R.I)	More than 70
Thermal Management	The LED modules shall be mounted on heavy duty heat sink.
Ceiling height 16m	The fitting shall be suitable for mounting high up to 16 meter.

36.14 **Low Bay LED Light Fitting – Type (H1)-**

Housing	- Ballast tank, splice box and cast guards corrosion resistant copper-free aluminium alloy. - Baked powder epoxy/polyester finish, electrostatically applied for complete, uniform corrosion protection. - All external hardware - stainless steel - Reflector - Aluminium
Diffuser	Tempered glass sealed with aluminium ring.
Power Consumption	Minimum 70 Watt, Maximum 80 Watt
Working Voltage	Voltage 240 VAC / Frequency 50 Hz.
Luminous efficiency	More than 91 LM/W as minimum.
Compliances	UL-8750 for LED lighting.
Colour temperature	5000 – 4000
Life time	50,000 hours
Guarantee	5 years
Working temperature	-10 to + 55°C as minimum.
Protection degree	IP66 as minimum.
Certifications	CE, RoHS, UL, LM79-08 Certified “Absolute” Photometry, including Chromaticity colour for Solid State Lighting.
Power Factor	More than 0.90
Total Harmonic Distortion (THD)	Less than 15%
Colour Rendering Index (C.R.I)	More than 70
Thermal Management	The LED modules shall be mounted on heavy duty heat sink.
Ceiling height 16m	The fitting shall be suitable for mounting high up to 16 meter.

HIGH BAY LED LIGHT FITTING TYPE (A13/2/58) used in Explosive atmospheres of gas or vapour (Division 2 areas as defined in UL-844 Standard for lighting fixtures for hazardous locations, Class I, Division 2

Housing	- Ballast tank, splice box and cast guards corrosion resistant copper-free aluminium alloy. - Baked powder epoxy/polyester finish, electrostatically applied for complete, uniform corrosion protection. - All external hardware - stainless steel - Reflector - Aluminium
Diffuser	Tempered glass sealed with aluminium ring.
Power Consumption	Minimum 80 Watt, Maximum 100 Watt
Working Voltage	Voltage 240 VAC / Frequency 50 Hz.
Luminous efficiency	More than 91 LM/W as minimum.
Compliances	- UL-8750 for LED lighting - UL 844 Standard for Lighting fixtures for hazardous locations Class 1, Division 2; Class II, Division 1 and 2, Class III.
Colour temperature	5000 – 4000
Life time	50,000 hours
Guarantee	5 years
Working temperature	-10 to + 55°C as minimum.
Protection degree	IP66 as minimum.
Certifications	CE, RoHS, UL, LM79-08 Certified “Absolute” Photometry, including Chromaticity colour for Solid State Lighting.
Power Factor	More than 0.90
Total Harmonic Distortion (THD)	Less than 15%
Colour Rendering Index (C.R.I)	More than 70
Thermal Management	The LED modules shall be mounted on heavy duty heat sink.
Ceiling height 16m	The fitting shall be suitable for mounting high up to 16 meter.

FLOOD LIGHT - Light Fitting Type B5/5 LED

Power Consumption	Minimum 200 Watt, Maximum 230 Watt
Working Voltage	Voltage 240 VAC / Frequency 50 Hz.
Luminous Flux	22000 - 24000 lm as minimum
Light colour	5000 K
LED service life	50,000 operating hours at L80 B10
Guarantee	5 years
Working temperature	The fittings shall be suitable for outdoor use (Kuwait climatic condition) where the maximum temperature may reach 84ºC at sirect Sun.
Protection degree	IP66 as minimum.
Certifications	CE, RoHS, UL
Power Factor	More than 0.90
Total Harmonic Distortion (THD)	Less than 15%
Colour Rendering Index (C.R.I)	More than 70
Housing	Anodized aluminium extrusion with steel powder coated (white colour). Tempered glass lens protects LEDs and allows for cleaning/debris removal.
Thermal protection	For over-temperature (92ºC)
Surge protection	3 KV
Thermal Management	The LED modules shall be mounted on heavy duty heat sink.
Listings	- IP65 fixture, driver RoHS compliant and IP66 - Listed to UL 1598 for use in wet locations
Certifications	- CE certified, VDE, UL approved list

FLOOD LIGHT - Light Fitting Type B5/3 LED

Power Consumption	Minimum 90 Watt, Maximum 100 Watt
Working Voltage	Voltage 240 VAC / Frequency 50 Hz.
Luminous Flux	10,000 – 11,000 lm as minimum
Light colour	5000 K
LED service life	50,000 operating hours at L80 B10
Guarantee	5 years
Working temperature	The fittings shall be suitable for outdoor use (Kuwait climatic condition) where the maximum temperature may reach 84ºC at sirect Sun.
Protection degree	IP66 as minimum.
Certifications	CE, RoHS, UL
Power Factor	More than 0.90
Total Harmonic Distortion (THD)	Less than 15%
Colour Rendering Index (C.R.I)	More than 70
Housing	Anodized aluminium extrusion with steel powder coated (white colour). Tempered glass lens protects LEDs and allows for cleaning/debris removal.
Thermal protection	For over-temperature (92ºC)
Surge protection	3 KV
Thermal Management	The LED modules shall be mounted on heavy duty heat sink.
Listings	- IP65 fixture, driver RoHS compliant and IP66 - Listed to UL 1598 for use in wet locations
Certifications	- CE certified, VDE, UL approved list

FLOOD LIGHT - Light Fitting Type B4/3 LED

Power Consumption	Minimum 40 Watt, Maximum 50 Watt
Working Voltage	Voltage 240 VAC / Frequency 50 Hz.
Luminous Flux	10,000 – 11,000 lm as minimum
Light colour	5000 K
LED service life	50,000 operating hours at L80 B10
Guarantee	5 years
Working temperature	The fittings shall be suitable for outdoor use (Kuwait climatic condition) where the maximum temperature may reach 84ºC at sirect Sun.
Protection degree	IP66 as minimum.
Certifications	CE, RoHS, UL
Power Factor	More than 0.90
Total Harmonic Distortion (THD)	Less than 15%
Colour Rendering Index (C.R.I)	More than 70
Housing	Anodized aluminium extrusion with steel powder coated (white colour). Tempered glass lens protects LEDs and allows for cleaning/debris removal.
Thermal protection	For over-temperature (92ºC)
Surge protection	3 KV
Thermal Management	The LED modules shall be mounted on heavy duty heat sink.
Listings	- IP65 fixture, driver RoHS compliant and IP66 - Listed to UL 1598 for use in wet locations
Certifications	- CE certified, VDE, UL approved list

36.15 LED FLOOD LIGHT FOR WALL WASH - TYPE (W)

Power Consumption	Minimum 240 Watt, Maximum 250 Watt
Working Voltage	Voltage 240 VAC / Frequency 50 Hz.
Luminous Flux	12000 lm as minimum
Light colour with colour change control.	White light ranging from cool (6500 K) to warm (2700 K)
Life time	80,000 hours
Guarantee	5 years
Working temperature	-10 to + 50°C as minimum.
Protection degree	IP66 as minimum.
Certifications	CE, RoHS, UL
Power Factor	More than 0.90
Total Harmonic Distortion (THD)	Less than 15%
Colour Rendering Index (C.R.I)	More than 70
Housing	Anodized aluminium extrusion with steel powder coated (white colour).
Thermal Management	The LED modules shall be mounted on heavy duty heat sink.
Wall Wash	The Flood light shall be suitable for wall wash.

36.17 LED LIGHT FITTING TYPE 'K' UP & DOWN WALL WASH LUMINAIRE

Degree of protection	IP 65
Housing	Dye-cast aluminium
Lumens LM	2 x 1800 Lm min.
Led life time	50,000
Type of mounting	Surface mounted
Power Consumption	2x 30 Watt Max.
LED reflector	Adjustable beam
Finishes	Silver
Diffuser	Tempered glass 4mm thick, shock and heat resistant.
Guarantee	5 years

Note: The fitting shall be suitable for operation in outdoor in Kuwait.

36.18 - **A. OBSTRUCTION LIGHT**

1. LED Obstruction light shall be cetified by FAA (Federal Aviation Administration)
2. Rated for 240V/50HZ, 0.9 P.F / 20 Watts maximum power.
3. Temperature ranging from -55º to +55º as a minimum, direct sunlight, wind rain, wind in excess of 150 mph, high humidity, salt, fog and shall be suitable for outdoor use in Kuwait.
4. Degree of protection IP 66.
5. Obstruction light supplier must have local agent with technical staff for assistance and product to be used in Kuwait for minimum 5 years and particularly in Kuwait Airport.
6. Dome shall be made of resistant polycarbonate or glass.
7. Guarantee – 5 years.
8. Life time: Minimum 100,000 hours.

B. PHOTOELECTRIC CELL CONTROLLER for Obstruction Light

Shall be certified by FAA and approved by Kuwait Civil Aviation Authority and shall provide with the following: -

1. Surge protection
2. LED power indicator
3. Cast-aluminium weatherproof box
4. Solid-state circuitry for high reliability
5. Light actuation: Energizes at 35 foot-candles, De-energizes at 60 foot-candles
6. Operation on 240 V 50 Hz frequency power.
7. Voltage tolerance ± 20%.

36. GENERAL PROVISION FOR CONTRACTORS

Specifications, or vice versa, or any incidental accessories necessary to make the work complete and perfect in all respects and ready for operation even if not particularly specified, shall be furnished, delivered and installed by the Contractor without additional expense.

All civil details for electrical rooms as doors, trenches, cable duct, etc., shall subject to the approval of Engineer and shall be executed by the Contractor without obligation.

The Contractor must take into consideration that the drawings provided are just to give the general picture and layout.

The Contractor shall be wholly responsible for the proper execution of the electrical installation section of the complete specification.

The Contractor shall replace any of the Sub-contractor's staff who in the opinion of the Engineer are not carrying out their respective works in a proper and efficient manner.

The Contractor shall verify the electrical requirements of all actual equipment's involved prior to the installation of electrical service to the same.

The Contractor shall furnish and install all supporting systems materials and incidentals necessary to support conduits, cables, D.B's switches, etc.

The electrical works will be considered complete only when the installations are duly tested by Engineer and there is power supply for the installations.

Socket and light fitting location should be co-ordinated with rack and equipment layout.

Contractor price will include all spare parts required, during maintenance period.

Contractor must comply with all technical specifications attached with this tender document. Any deviations from the stated technical specifications must be reported on a separate sheet, showing the deviation and giving the reason or justification.

Successful contractor will have to co-ordinate the time schedule with the Engineer. Contractor has to submit a weekly work schedule, to be approved by the chief of services, at least one week prior to commencing work. All form must be computer generated.

All electrical panel and control panels shall be manufactured within six (6) months from the date of signing the contract.

Successful contractor will have to establish a training program for the M.E.W staff at each site on the operation and maintenance of the system. A formal training program will have to be established with co-ordination and approval of the chief of services of the complex.

The location of Starter have may services such as HT cable and LT cable control cable for piping, ... etc., so should any obstruction be discovered while digging, it will be the responsibility of the contractor to reroute and re-located the services.

Contractor must respond emergency call to rectify and correct any system malfunctions or equipment breakdown. Such emergency call has to be done within four hours day or night, whenever the call is placed.

Contractor is to guarantee parts availability for all equipment's for a period not less than 10 years.

Contractor is to provide operator training and subsequent refresher training to assure that all operators are proficient in system operation. Contractor is to provide any training requested by the Ministry for new operators.

36.1 Maintenance Operation Period

There shall be two years maintenance period for all work and equipment's under the contract.

This period starts from the successful completion of one month reliability test period.

Maintenance shall include: -

A. Routine maintenance (Daily, Weekly, Monthly, and Yearly).

B. Repair and replacement of defective parts and installation which include all labour and material (lamps, control gear, electronical cards, oil of D/G, Filter, camera, elevator, spare parts. … etc.

C. Maintenance staff of the contractor shall be available on call at the contractor's premises on 24 hours basis. In addition, the contractor shall provide a site three qualified technicians having at least 10 years' experience in operation and maintenance of Building Management System and above working in shifts on 24 hours basis including Fridays and holidays. A penalty of KD. 100/- per day shall be applied for any unjustified absence of technician.

D. Equipment Inspection:

1. Main low tension panels, final distribution boards and control panels for all equipment shall be inspected by specialist factory Engineers at least once a year for ensuring good working condition for all protection devices. Test and inspection certificates are to be forwarded to the Engineer.
2. Building Management system shall be inspected once a year by the approved agent of the installed system.
3. All Diesel Generators shall be inspected by the Manufacturer's Service Engineer every six months, in the presence of the Engineer. Any additional routines/repairs likely to be recommended by the manufacturer shall also form part of this Contract.
4. The Fire Fighting and Fire Alarm System shall be inspected by the Fire Brigade Annually.
5. All Lifts shall be inspected by BUREAU VERITAS or equal approved and manufacturer's service Engineer at least every year.

Note: All expenses for the visit and inspection carried out by the Manufacturer's Service Engineer and Lloyd's or BUREAU VERITAS or equal approved Representative shall be paid by the Contractor and shall be part of this Contract.

E. **Maintenance Management System (MMS)**

Contractor shall provide MMS software (original approved) within Ten (10) months of signing the contract. A penalty of KD.100/- shall be imposed for everyday of delay, starting from the date of completion.

The software shall be capable of alerting when the maintenance is due, preparation of work orders automatically, generation of weekly/monthly report of all activities; maintain equipment data, history and cost. The operation and maintenance of the software shall be carried out by the contractor's project engineer for planning and follow-up. The contractor shall supply two (2) nos. latest computers and two (2) nos. LaserJet colour printers to MEW engineer's office, in addition to the hardware required to be installed in Control room. MEW engineer shall be able to access the various reports generated by the software through internet from his office computer.

F. Planned Preventive Maintenance on Maintenance Management System Program:

The contractor shall be provided computer program for maintenance similar to MMS for PPM routines are classified as Weekly (W), 2-Weekly (2W),

Monthly (M), 3-Monthly (3M), 6-Monthly (6M), Annual (A) and occasional (0). They shall also include those routines based on completed running hours of the equipment for, e.g., 500 hourly routine, 1000 Hourly routine, 5000 Hourly routine, 10,000 Hourly routine and shall submit daily report to MEW engineer. If the contractor failed to submit daily maintenance report to the MEW engineer as specified above, KD. 100/- per day shall be imposed as penalty.

G. If the contractor during the maintenance period fails to respond to any necessary repairs called for by MEW within 24 hours after being notified, MEW reserves the right to impose penalty KD. 200/- per day and execute the repair under the full responsibility of contractor and charge the contractor the cost of those repairs without accepting any claims from the contractor's side.

37. RENOVATION OF MUTLA RECIRCULATION PUMPING STATION AND CONTROL ROOM

38.1 Rennovation of existing Low Voltage switchgear, Automatic transfer switch, Electrical Panel, and Distribution boards at existing Mutla recirculation Pumping station, switch gear and control room. The renovation work shall be included the following: -

38.1.1 Replace all existing ACBs in all existing electrical panels by new ACBs as per specification, item # 9with same rating with rupture capacity 70 KA and connect the data to Building automation and SCADA system.

38.1.2 Replace all existing MCCBs or switch fuse in all existing electrical panels by new MCCBs as per specification, item # 10 with same rating with rupture capacity 70 KA and connect the data to Building automation and SCADA system.

38.1.3 Replacing all existing distribution boards by new DBs with new miniature circuit breakers with built in earth leakage for each circuit.

38.1.4 Replacing existing automatic transfer switch by new automatic transfer switch as per item # 13 complete with Bypass switch with all modifications required in control circuit and power cable and connect the data to building automation and SCADA system.

38.1.5 Replacing of all indication lamp in all existing electrical panels by new LED indication Lamp as per specification in all electrical panels.

38.1.6 Replace all measuring instruments in all existing electrical panels i.e. (ammeter, volt meter, current transformer, voltage transformer and selector switch) by new digial ammeter, digital voltmeter as specification of the project and connect the data to Building automation and SCADA system.

38.1.7 Replace existing Motor Control centre by Intelligent Motor control centre as per specification and send the data to building automation and SCADA system.

38.1.8 All required electrical installation and necessary new power and control cables for the renovation of Mutla recirculation pumping station and control room.

38.1.9 Replace all switches, sockets, JBs, double pole switches by new one as per specification.

38.1.10 Re-wiring all existing electrical installation for light, power and control, and replace all existing weatherproof enclosure, MCCB, Switch fuse by new weatherproof enclosure and MCCB as per specification and completerenewal of earthing system

38.1.11 Replace all existing light fittings for indoor and outdoor by new LED lamp, LED light fittings as per specification.

38.1.12 During the renovation of existing electrical panel, the contractor shall supply temperorary panel panel and portable Diesel Generator with sufficient capacity to avoid interruption of power supply during renovation of existing panel or dismantling the existing panel and supply new panel.

38.1.13 All required civil and builder's work associated with electrical work fo renovation of existing Mutla recirculation pumping station and control room shall be done by contractor.

38.2 Renovation of all electrical panels (MLTB, MSB, SMSB, DB, MCC, and ATS) shall be done by contractor through approved manufacturer of Low Voltage Panel and the manufacturer shall give 5 years warranty for all the panels after renovation.

38.3 All the panels after modification shall be tested by Third Party.

39. INSPECTION AND TESTING AT MANUFACTURER'S PREMISES AND AT SITE:

39.1.1 Inspection and Testing shall be done at Manufacturer's premises and at site by Third Party Inspection Authority.

13.8.2 Scope of Work for inspection of Third Party at Manufacturer's premises and at site for the following items: -

a. PV panel
b. Inverter
c. Inverter in weatherproof enclosure
d. Load Management system

e. Transformer
f. Combiner Box
g. Cables , ..etc., and all other equipment, as per specification.
h. LED light fitting for the whole project
i. Elevator for the whole project
j. UPS for the whole project
k. Electrical panels (MLTG, MSB, MCC, SMSB, DBs for the whole project.

13.8.3 Before taking-over of the plants, Plants will be inspected and tested by Third party as per IEC/EN 62446-2010 – Grid connected photovoltaic systems – Minimum requirements for system documentation, commissioning test and inspection. PR test will be conducted as per IEC 61724 – Photovoltaic system performance monitoring – Guidelines for data exchange and analysis. Any correction suggested needs to the incorporated in the plants.

13.8.4 Before ending the guarantee period the contractor shall inspect all equipment in the project and PV system by Third Party as per item 13.8.3

13.8.5 The test shall be according to latest IEC including performance, safety, protection, compliance with specification, etc. The cost of inspection shall be paid by the contractor.

13.8.6 In case of delay of inspection and testing by Third party, the Ministry has the right to choose any Third party inspection under full responsibility of the contractor and charge the contractor the cost of those inspection plus 10% administrative charges without accepting any claims from the contractor's side.

THIRD PARTY INSPECTION AUTHORITY FOR PV SYSTEM & ALL EQUIPMENT FOR THE WHOLE PROJECT

The contractor should propose at least three Third Party Authorities for any required inspection to be conducted on the project as per the bill of the quantities, and MEW has the right to select the appropriate from the proposed list on every time the test to be done.

LIST OF APPROVED THIRD PARTY INSPECTION AUTHORITY FOR PV SYSTEM, LOAD MANAGEMENT SYSTEM, LIGHT FITTING, ELEVATOR …ETC.

SL. NO.	ORGANIZATION	FULL NAME
1	LR	LLOYD'S Register
2	ABS	American Bureau of Shipping
3	TUV	Rhenish West Falischer Technicher Uberwachunges Veren
4	DNV	Det Norske Veritas

5	BV	Bureau Veritas
6	GL	Germanischer Lloyd
7	RSA	Royal Sun Alliance
8	HSB	Hartford Steam Boiler
9	SGS	Societe General du-Service

46. SUPPLY, INSTALLATION AND OPERATION OF PHOTOVOLTAIC POWER SYSTEM ON ROOF OF THE BUILDING

This section covers all the works described to be completed in every respect for commercial operation to the requirements of the engineer. Notwithstanding that any details, accessories, etc., required for the complete installation and satisfactory operation, such works shall be included in the tender.

1. ELECTRICAL SUPPLY:

Voltage (3phase 4 wire):	400V+10% or – 6%
Voltage (single phase):	230V+10% or – 6%
Frequency:	50 HZ +4%
Nuetral:	Solidly earthed
Fault level:	31MVA at 415 V
Fault operation:	0.15s

Note: The tenderer shall submit along with the tender, catalogues, to prove that the equipment rating of volts and frequency are as specified.

2. STANDARD REGULATIONS:

2.1 All electrically operated equipment and materials shall comply as minimum unless otherwise specified.

A) With latest relevant recommendations of the International Electrical Technical Commission (IEC) if available.

B) If (a) is not available with the latest relevant British Standards specifications (BSS).

C) MEW – R1

D) Notes mentioned on the tender drawings.

2.2 The electrical wiring including earthing shall fully comply with rules, regulations and standards specification of electrical installation work by MEW.

4. PHOTOVOLTAIC MODULES

4.1 General

4.1.1 Description

A. Introduction

PV Modules convert light directly into electrical energy. State-of-the-art application Technology and product compatibility are required to ensure Low "life cycle cost" and high reliability. Besides, the panels shall withstand the harsh environmental conditions prevailing in Kuwait. All the PV modules should be suitable to use in the desert area Potential-induced degradation free (PID free).

B. **Scope:**

Supply and Install Photovoltaic modules as part of the PV Power system and in accordance with the requirements of contract documents.

4.1.2 Quality Assurance:

A. **Applicable standards**:

1. IEC 61215 for crystalline silicon PV modules
2. TUV Safety Class II (IEC 61730)
3. UL 1703 for flat plate photovoltaic modules and panels.
4. ASTM & ISO standards relevant to PV Panels.

B. **Approved Manufacturers**:

A list of Approved Manufacturers is given as "Attachment". Other manufacturers fulfilling the following requirements shall be considered for approval.

ISO 9001 and 14001 certification with minimum 10 years' experience in manufacturing of PV modules with UL listing and TUV or equivalent internationally reputed 3rd Party Certification.

Minimum Plant capacity 50 MW/year.

Plant location shall be in North America, Europe, Japan or Australia.

Must have proven R&D (Resource & Development) facility.

Shall have "Module collection and Recycling Program", through which the PV modules at the end of their useful life shall be collected and recycled into new products including new solar modules.

4.1.3 **Submittals**:

A. Product Data – Submit manufacture's specifications, performance data, installation and maintenance instructions.

B. Fill up the relevant Technical Schedule in Section VI

C. Test Certification

Provide test certificate from TUV or an internationally reputed third party inspection authority verifying the performance rating at STC (standard testing conditions 25ºC cell temperature, 1000 watts per square meter solar irradiance air mass equal to 1.5, and ASTM G173-03 Standard Spectrum).

4.2 **Products – Photovoltaic Module**

1) A number of solar modules shall be connected in series and parallel to form a solar array to give the required parameters.

2) The solar modules shall meet the requirements of:-

A. The Photovoltaic Modules Performance Test Specification IEC 61215

B. Repetitive humidity – freezing cycling Test between +85ºC, 85% humidity and 40ºC

C. The salt spray test according to IEC 68-2-11.

Note: These are all basic tests that simulate the climate in as far as it affects the working of the solar module.

4.2.1 The solar module efficiency shall be in the highest range available in its industrial category for commercial application. However cost per kilowatt per hour of energy output shall be the main criteria in selection of PV modules.

4.2.2 The solar module shall have high transmittance tempered glass which allows more lights to reach the solar cells.

4.2.3 The module shall have a back film to increase weather resistance and to aid light absorption.

4.2.4 The solar module's glass shall have anti-reflective coating to improve transmission of Light and to protect module against heat.

4.2.5 The solar module shall be mono-crystalline with efficiency more than 16% and have solder free cells to improve cell efficiency.

4.2.6 The solar modules shall be mounted on a supporting structure constructed from corrosion resistant material and suitable for installation at the specified site.

4.2.7 The solar modules shall not be shaded.

4.2.8 The solar module's own frame shall be supplied with holes or slides for mechanical attachment and be made of corrosion resistant material.

4.2.9 Electrical connection shall be made on a sturdy terminal bloc in an IP66 junction box (or better) in which two (2) by-pass diodes shall be incorporated to prevent hot spots.

4.2.10 The electrical characteristics of the solar modules shall be stated with the solar parameters, and be listed on a non-removable sticker on the back side of the solar module.

4.2.11 The solar module shall have an IP54 as minimum rated junction box with cable glands and a terminal block that are fit for cables of minimum of 4mm².

4.2.12 The solar module should have an individual serial number behind the front glass.

4.2.13 The solar module shall be manufactured by 2015 or latest and have a performance warranty of minimum 25 years with power output of 80%.

4.2.14 If the modules are installed at a significant distance from the load and/or battery, attention shall be given to the selection of the output voltage and/or diameter of the cabling to avoid unacceptable energy losses.

4.2.15 Normal engineering principles shall be applied to ensure that the modules and mounting are adequately strong enough to withstand extreme temperatures and temperature fluctuations, high atmospheric humidity, strong winds and sandstorms.

4.2.16 Where requested the solar modules shall be certified for use in a Zone 1 hazardous area in accordance with the ATEX standards.

4.2.17 Site and panel temperatures shall be taken into account for the performance of the solar modules.

4.3 **Execution – Installation**

4.3.1 The installation shall be carried out according to manufacturer's installation and safety instructions, supervised by manufacturer's specialist.

4.3.2 PV modules shall be installed in a location where there is no shading throughout the year.

4.3.3 PV modules shall face sun directly to ensure maximum output power. The PV modules shall be mounted on support structure designed for fitting for optimum absorption of solar energy.

4.3.4 The installation shall ensure adequate accessibility for easy maintenance.

5. MOUNTING SYSTEM

General

5.1 Description

Mounting system is used for mounting solar modules on roof of the building and shall be of modular unit construction. The system shall be universal in nature and shall enable the installer to mount any module in practically any mounting situation.

5.1.1 **Scope:**

Supply and install mounting system suitable for the PV modules, as part of the PV Power System and in accordance with the requirements of the contract documents.

5.2 Quality Assurance

Quality assurance shall be carried out pursuant to DIN EN ISO 9001:2000 or other equivalent International Standards and shall carry a life time guarantee of 25 years.

5.3 Submittals

Product Data – Submit manufacturer's specifications, installation and maintenance instructions.

Fill up relevant Technical Schedule.

Product warranty certificate.

5.4 Product –Mounting System:

5.4.1 The mounting system shall be suitable for commercial solar installations and shall be manufactured by a specialist company with at least 5 years' experience in manufacturing and delivering solar racking and mounting system. The Manufacturers shall have ISO 9001 and ISO 14001 certification.

5.4.2 The mounting system shall be designed as modular unit construction system and shall enable the installer to mount any module in practically in any mounting situation.

5.4.3 All the components except the fasteners shall be of high quality corrosion resistant aluminum. All fasteners including nuts and bolts shall be of 316 stainless steel.

5.4.4 The mounting system shall be capable of withstanding the wind loads prevalent in Kuwait and shall also withstand the harsh environmental conditions prevailing in Kuwait.

5.4.5 The mounting system shall have the provision for adjusting the tilt angle of the PV modules to ensure maximum exposure to sun light.

5.5 **Installation:**

5.5.1 The installation shall be carried out according to manufacturer's installation and maintenance instructions.

5.5.2 The installation shall ensure adequate accessibility for maintenance.

5.5.3 The installation shall ensure optimum inclination for the PV modules to ensure maximum power output.

6. AUTOMATIC WASHING SYSTEM

1. General

The system shall consist of but not limited to GRP water tank, Booster Pump Set, water filter, soap concentrate, soap injection pump, pipe network, nozzles, control valves, controllers, necessary hard and software. The system shall be designed by the manufacturer of the automatic washing system and shall be installed according to the Manufacturer's recommendations. The offered system shall have been in satisfactory operation under similar weather conditions, for a minimum period of two (2) years and the contractor shall furnish necessary proof. Further a certificate, from the Manufacturer of the PV Panels, stating that the proposed automatic washing system is suitable for the PV Panels, shall be required to be submitted along with the submittal without which the system shall not be considered for approval. The approved system is Heliotex USA or equal.

The washing system shall have provision for monitoring and to be controlled remotely from Integrated Building Management System, where applicable, via software interface using standard protocol such as : -

- LONtalk
- Modbus
- BACnet
- OPC.

2. GRP Water tanks:

2.1. General:

The manufacture and installation of Hot Press Moulded GRP Sectional Water Storage Tanks shall conform to BS 5750: Part 2: 1987/ISO 9002/EN29002 and shall be covered by a Certificate of Conformity stating the manufacturer's approval number and name of the approved body.

2.2 Manufacture:

Tanks shall be hot press moulded, glass reinforced plastic, moulded at a closely controlled temperature of 140ºC.

The material shall be medium pale blue/grey colour and shall include a minimum 30% glass content, Isophthalic Polyester resin throughout and U.V. Stabilizer conforming to BS 5734: Part 5: 1980.

The tank design shall incorporate truncated pyramid shape meter square or meter by half-metre panels and corner angles manufactured to a tolerance of +/-0.5 mm.

All surfaces of the panels shall be smooth and crevice free to provide hygienic finish. Flanges shall be factory drilled.

Heavy-duty covers shall be self-draining type, complete with 850 mm square bolted access door, air vent with insect screen not exceeding 0.65 mm aperture, but with an open area of 37%.

All tanks deeper than 1.5m shall be fitted with internal GRP and external aluminum access ladders. Access ladders shall generally be to the requirements of BS 4211.

Where a tank is divided into two compartments, a full height partition made from standard panel shall be provided and be capable of working normally with one side empty. Each compartment to have provision for access doors and air vents as detailed above.

2.3 Bracing:

The tank shall be braced by a combination of external galvanized RHS (rectangular hollow section) supports and internal 304 quality stainless steel tie rods.

The tie rods shall be attached to the vertical RHS supports to provide continuous bracing to the flanges of the tank panels and have a means of pre-tensioning that eliminates point loads.

2.4 **Base Supports**:

Tanks shall be installed on flat reinforced concrete bases or on steel beams conforming to manufacturer's specification of flatness and deflection.

2.5 **Sealant** :

Sealant for joint in tank panels shall be Butyl Rubber compound with minimum of 25% recovery from compression. Joints shall be 3-mm thick and cover the full panel flange.

2.5.1 **Installation:**

Bolts which come into contact with water shall be minimum 12mm diameter 304 quality stainless steel bolts.

2.5.2 The tank size and capacity shall be according to the design by the manufacturer of the automatic washing system.

2.6 **Testing:**

Tanks and each compartment shall be tested undertaken on completion of installation. There shall be no visible sign of water leakage over a minimum period of 24 hours.

3 **Booster pump set:**

a) Provide for each system, one self-contained, fully automatic packaged unit duplex pump set (each set: 2 pumps – one duty, one standby) complete with control panel and accessories and mounted upon a fabricated steel base. Pump casing, shaft and impeller shall be of 316 Stainless Steel constructions.

Pressure setting shall be adjustable to provide water at a constant pressure. Pumps will be automatically sequenced to work alternatively to reduce wear & tear and should be operated by the automatic controller of the washing system.

b) Electric motors shall be totally enclosed, fan cooled with Class F insulation.

c) Control panel shall be designed to comply with IEE wiring regulations, latest edition. Protection shall be provided from both direct and indirect contact by earthed potential bonding and earth leakage circuit breakers.

d) Control panel equipment shall be complete with all necessary terminals, labels, interconnections, wiring and fuses. Control panel shall be constructed from sheet steel, dust and damp protected IP54 housing with anti-condensation heater and lockable door, requiring one incoming three phase, four wire electrical supply to the main isolator. All control panel labeling shall be in both English and Arabic.

e) Control panels should include pump selector switch, starters, and indicating lamps. The control panels will be designed and wired for automatic sequencing as specified above and shall also provide automatic switch over to second pump upon working pump failure.

f) Pump sets shall be protected against dry running by relay cut-off. Provide a warning lamp on the control panel to indicate when the cut-off is in operation. The pump set shall automatically resume operation when normal condition returns.

g) Pipe work, valves and fittings shall be as. Flexible connections shall be provided to both suction and discharge pipe work connections.

h) Pumps are of vertical, multi stage, and centrifugal type.

i) System piping shall be table "Y" copper brazed joints. Manifold ends shall be flanged.

j) Valves: All bronze valves at suction and discharge of each pump and bronze water type self-closing (non-slam) check valve at discharge of each pump.

k) Brass frame: Fabricated steel with resilient mounting for pumps, where required.

l) Relief Valve: Bypass pressure relief valve shall be provided from discharge to suction manifolds to prevent pump operation at shutoff head.

m) Accessories: Compound gauge at suction manifold and pressure gauge at discharge manifold, flexible connections at suction discharge connections and pressure switches.

n) Finishing: The assembly shall be given two coats of primer and one coat of gloss enamel at the factory.

o) Capacity: The flow and the head shall be according to the calculations given by the automatic washing system manufacturer.

p) Approved Manufacturers: GRUNDFOS, K.S.B, EBARA or equal.

4. Water Filter

The filter shall be cartridge type housed in heavy duty 316 Stainless Steel casing, rated for the flow requirement of the system. The design working pressure shall be 10 bar at 75^0C.The cartridge shall be of polypropylene material grooved type which shall remove turbidity, algae, sediment, dirt, rust and particulate contaminants down to 5 micron in size. Approved manufacturers: Cuno or equal.

5. Soap concentrate & soap injection pump

The soap concentrate and injection pump shall be supplied/recommended by the manufacturer of the automatic washing system. The soap concentrate shall be safe to handle and non-inflammable. Certified material safety data sheet shall be supplied for approval before ordering the material. Spare quantity for 2 years operation shall be supplied in sealed drums, in addition to providing required quantity during guarantee period.

The soap pump shall be designed for a working pressure of 10 bar with a maximum fluid temperature of 50^0C.All components shall be resistant to chemical action of the soap concentrate. The following shall be the materials of construction.

- Pump head: PVDF

  Pump head inlet and outlet valves

- Valve body: PVDF
- Tube adapters: PVDF
- Check balls: Ceramic
- Suction tubing : Clear PVC
- Discharge tubing: Natural polyethylene

  Suction foot valve/ strainer

- Body and tubing adapter- PVDF
- Strainer –Polypropylene

6. UV Resistant pipe

The pipes and fittings shall be of multilayer UV resistant polypropylene with an SDR (Diameter to thickness ratio) of 7.4 and shall withstand 95^0C.The pipe shall provide satisfactory performance for a period of 25 years with a service pressure of 15 bar and temperature of 50^0C.

The installation shall be carried out as per the recommendations of the manufacturer of the pipes. The distance between supports shall be generally according to the following table.

Table : Support Spacing

Pipe Size (nominal) mm	Support Spacing mm
16	500
20	550
25	650
32	750
40	850
50	1000
63	1150
75	1250
90	1400
110	1600

Expansion loops shall be provided to cater for expansion of pipes. The contractor shall prepare expansion calculations as recommended by manufacturer and submit for approval. Standard clamps and hangers shall be used for supports. Field fabricated clamps and hangers shall not be accepted.

Approved make: - Poloplast, Germany or equal.

7. Nozzles

The nozzles shall be of Matched Precipitation Rate (MRP) type, designed for an optimum pressure of 30 psi and shall meet the requirements of the manufacturer of the automatic washing system. The nozzles shall be UV resistant plastic and shall withstand the high outdoor temperature. The radius adjustment screen, pressure compensating screen and flow and radius adjustment screw shall be constructed of 316 stainless steel. Certificate of conformity from Manufacturer of the automatic washing system shall be attached along with the submittal of the nozzle for approval.

8. Valves

Gate Valves shall be used for isolating purposes, Globe valves shall be used for regulating purposes and check valves shall be used for non-return purposes.

Valves of sizes 2” and smaller shall be of all bronze construction type with inside screw non-rising spindle, screwed bonnet, and screwed ends to ASTM B-61, B-62 or of gunmetal to BS 1400/LG2.

Valves of size 2½” and larger shall be of flanged bonnet and flanged ends, outside screw rising spindle type. Body, wedge and cover shall be of cast iron, wedge facing rings and stem nut of gunmetal and spindle of aluminum bronze. Steam seal packing shall be of high quality suitable for Kuwait climate.

Check valves shall be spring loaded silent type with SS spring.

9. **Strainers:**

Strainers shall be provided at the Suction side of the pump
Strainers shall be of Class 150 saturated steam-working pressure.

Strainers shall be Y-type.

Strainers shall be of same size as the connecting pipe.

Strainers for 2" pipe size and smaller shall be bronze body with stainless steel screen and screwed ends.

Strainers for 2½" pipe and larger shall be cast iron body with stainless steel screen and flanged ends.

Screen perforation shall be as follows:

Pipe size	Number of perforations per Sq. Cm.
Up to 2"	64
2½" and larger	23

10. **Pressure gauges:**

It shall be at least 150 mm. nominal diameter and shall confirm in all relevant requirements to the class 1 industrial concentric scale gauge as specified in BS 1780 Part 2. The dial shall be provided with a stop in the zero position.

The total scale be so chosen from BS 1780 part 2 that the operating pressure is between 40% and 75% of the scale range, each dial shall have the following information marked upon it.

a. Operating pressure in red
b. Maximum permissible working pressure in purple.

All pressure gauges shall be fitted with a siphon pipe and a cock adjacent to the gauges in such a manner that the gauge may be shut off and removed while the line is under pressure. Where a cock is fitted, the handle shall be parallel to the bore of the cock when the cock is open.

The cock shall have a connection for the attachment of a test pressure gauge; this connection shall be tapped 3/8" and shall be fitted with an easily removable plug.

The pressure gauges shall have dual calibration both in PSI and Kg/cm².

Note: **For controls refer to "Load Management System".**

7. INVERTER

7.1 General

7.1.1 Description:

Introduction:

Inverter is used to convert the direct current (DC) electricity generated by photovoltaic array into alternating current (AC) for stand-alone system or grid connected system.

Scope:

Design, supply and install inverter as part of the PV Power system and in accordance with the requirement of contract document.

Quality Assurance

Standards complied:

IEC 61727: Characteristics of the Utility Interface.

IEC 62109: Safety of Static Inverters

IEC 62116: Testing procedure of Islanding Prevention methods for Utility-Interactive Photovoltaic Inverters.

IEC 60364-7-712: Electrical Installations of Buildings: Requirements for special installations or locations – Solar Photovoltaic Power supply systems.

DIN VDE 0126 German Safety Standard.

Acceptable Manufacturers:

A list of approved manufacturers is given as attachment. Other manufacturers fulfilling the pre-qualification requirements given at paragraph 16.2.2 will also be considered.

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Submittals:

Product Data: Submit manufacturer's specifications, performance data, installation and maintenance instruction.

Fill up the relevant Technical Schedule.

Test Certification – Provide test certificate from UL or an internationally reputed third party inspection authority verifying the performance.

7.2 **Products**

7.2.1 **Inverter**

The DC power produced is fed to inverter for conversion into AC. In a grid interactive system AC power is fed to the MEW grid at 415V three phases or 220/240 V single phase system line depending on the system installed. Power generated from the solar system during the daytime is utilized fully by powering the captive loads and feeding excess power to the grid.

The inverter output shall be 415V Three-phase with neutral.

The AC output of the inverter must synchronize automatically with the AC voltage and frequency of the grid.

In a solar PV system without battery or with battery the inverter continuously monitors the condition of the grid and in the event of grid failure; the inverter automatically switches to off-grid supply within 20 to 50milliseconds. The solar system is resynchronized with the grid within two minutes after the restoration of grid. Grid voltage is continuously monitored and in the event of voltage going below a preset value and above a preset value, the solar system shall be disconnected from the grid within the set time. Both over voltage and under voltage relays shall have adjustable voltage and time settings.

The type of inverter shall be Grid-Tie inverter and shall be suitable for operating temperature from -10 ºC to 50ºC.

The inverter shall be so designed as to operate the PV system near its maximum Power Point (MPP), the operating point where the combined values of the current and voltage of the solar modules result in a maximum power output.

The Inverter shall be Industrial withdrawable modular type.

The inverter shall be a true sine wave inverter for a grid interactive PV system.

In case of system with battery, inverter also monitors the state of Battery Voltage, and performs switching operations to ensure that battery is charged continuously.

AC current distortion shall be less than 5% THD (Total harmonic distortion).

The inverter shall be provided with following protection as minimum:-

AC Over/Under Voltage

Over/Under frequency

Over temperature

AC and DC over current protection.

DC over-voltage

Reverse power protection.

Voltage surges.

Disconnector AC & DC integral to inverter assembly.

The inverter shall be provided with liquid Crystal display (LCD) to provide instantaneous information for the following as minimum: -

Power level

Daily and life time energy production

PV array voltage and current

Utility voltage and frequency

Time or line fault message.

The inverter shall be provided with communication software graphical interface to show overview of the status of the system in real time connection and communication directly with a PC or via a modem.

The degree of protection of the indoor inverter panel shall be at least IP 31 and that of outdoor at least IP-66 and shall be provided with built-in air-condition unit 12000 Btu.

The inverter shall be manufactured by 2015 or latest. The warranty for inverter shall be minimum 25 (twenty-five) years from the date of handing over the project.

The minimum efficiency at rated output shall be 96%.

7.2.2 **Charge Controller**

Normally in a solar PV system with battery, battery is first charged from solar system through Charge Controller. A charge controller monitors the battery's state-of-charge to ensure that when the battery needs charge-current it gets it, and also ensures the battery isn't over-charged. Connecting a solar panel to a battery without a regulator seriously risks damaging the battery and potentially causing a safety concern.

Charge controllers (or often called charge regulator) are rated based on the amount of amperage they can process from a solar array.

The charge controllers shall have Low Voltage Disconnect (LVD) and Battery Temperature Compensation (BTC). The LVD feature permits connecting loads to the LVD terminals which are then voltage sensitive. If the battery voltage drops too far, the loads are disconnected preventing potential damage to both the battery and the

loads. BTC adjusts the charge rate based on the temperature of the battery since batteries are sensitive to temperature variations above and below.

7.2.3 **Grid Charger**

In a grid interactive solar PV system with battery, a grid charger can also be provided which charges the battery taking AC power from the Grid in case solar power is not sufficient to charge the battery or battery voltage is very low. This may happen during the continuous cloudy days.

7.2.4 **Surge Arresters**

The inverter shall be with surge arresters as per IEC 61643 to protect inverter and solar power system for surge voltage.

7.3 **Execution:**

7.3.1 The installation shall be carried out according to manufacturer's installation ` and safety instruction and according to the site conditions.

7.3.2 The inverter for indoor shall be housed in weatherproof enclosure IP43 as minimum supplied by inverter manufacturer only complete with the following:-

i) Inverter complete with monitoring control unit and quality meter.

ii) Surge arrestors

iii) MCCB for DC Isolation for power output from PV array.

iv) MCCB for AC Isolation for power output.

v) Harmonic filter.

vi) Power transformer to modify the output on inverter to 415/240V 50Hz with neutral.

vii) Load Management System complete with UPS.

viii) Ventilation System.

ix) SMSB for container for feeding power to the following: -

a) Inverter control circuit
b) Ventilation system for container
c) Load Management system
d) Power meteorological station
e) DB for external light at shed.
f) Automatic washing system
g) All other equipment required to operate PV solar system in an operation condition.

7.3.3 The inverter for outdoor shall be housed in weatherproof enclosure (IP54), thermally insulated similar to cold store (4" thick polyurethane or equivalent insulation) with two nos. of A/C Unit, one running and the other standby (air condition).

Thermal insulated weatherproof enclosure shall be supplied by the inverter manufacturer only and shall contain the following: -

i) Inverter complete with monitoring control unit and quality meter.

ii) Surge arrestor.

iii) MCCB for DC Isolation for power output from PV array

iv) MCCB for AC Isolation for power output.

v) Harmonic filter

vi) Install temperature control and alarm buzzer and flash light outside the container to notify if the temperature of the container increased more than the specified limit, and shut down the inverter.

vii) SMSB for container for feeding power to the following: -

a) Inverter control circuit

b) Air-condition system for container

c) Load Management system

d) Power meteorological station

e) DB for external light at shed.

f) Automatic Washing system

g) Light and power socket inside the container.

h) All other equipment required to operate PV solar system in an operation condition.

viii. Power transformer for modifying the output on inverter to 415/240V 50Hz with neutral.

ix. LED light fitting for internal and external light for container.

x 3 nos. 13 A Industrial socket

xi. Load Management system.

xii Meteorological Station at Roof.

xiii. PV Panel cover complete on roof.

xiv Fire alarm and firefighting system as per KFD requirement.

Attn.: 1) Offer without full details of Inverter inside weatherproof enclosure complete with all equipment and panel as per specification shall be rejected.

2) Testing of inverter complete with all equipment inside weatherproof enclosure shall be done at manufacturer's premises, certified by MEW approved Third Party.

3) Outdoor weatherproof enclosure for inverter shall be guaranteed for 25 years as minimum to withstand the harsh Kuwait climatic conditions.

7.4 Details of Transformer connect to Output of Inverter

7.4.1 Type:

Three phase, Cast-Resin, naturally cooled, core type power distribution transformer.

The transformer shall be in accordance with the IEC No. 60076-11 or equivalent except where stated otherwise.

7.4.2 Installation:

Generally the Transformers will be installed outdoor and will be exposed to direct sun rays and thus they shall be capable of carrying their full rated current under Kuwait's worst temperature conditions as specified.

7.4.3 Normal Rating:

The normal rating shall be the maximum continuous rating under the worst temperature conditions encountered in Kuwait.

7.4.4 Tenderers shall state in the schedule the equivalent British Standard specification or the International Electro-Technical Commission rating for the transformer offered.
The Kuwait continuous rating should not be more than 80% of British Standard specifications continuous rating. Both the Kuwait and B.S. rating shall be based on the specified rated voltage.

7.4.5 Voltage Ratio:

The normal voltage ratio shall be as recommended by Manufacturer of Inverter.

7.4.6 Under Fault Conditions:

The transformers shall be capable of sustaining a three phase symmetrical short circuits current on the L.V. side with the fault power being maintained on the H.V. side and without damages to the transformers for three seconds.

7.4.7 **Impedance Voltage:**

The impedance voltage at normal rating and voltage, and at 115 degree centigrade shall be 6 % and stated in the schedules.

7.4.8 **Temperature Rise:**

The transformers shall be capable of carrying its full normal rated current continuously under the worst temperature conditions encountered in Kuwait, and at any tapping, without the temperature rise of winding (both H.V & L.V) exceeding 80 degree centigrade measured by resistance.

Any transformer exceeding the above temperature rise limits will be rejected:

7.4.9 **Connection & Ratio:**

The transformers are to be wound to International Electro-Technical commission No. 60076, Vector symbol Dyn. 11 with normal voltage ratio on normal tapping at no load and neutral point brought out on L.T. side.

7.4.10 **Cooling:**

The transformers shall be cooled by natural circulations of air, and due note should be taken of the site conditions.

7.4.11 **Cores:**

The core shall be constructed of the best quality low loss, cold rolled, grain oriented electrical steel laminations.

The flux density in any part of the core shall not exceed 1.6 TESLA at normal voltage and frequency.

All core plates shall be insulated from one to another to reduce the loss to a minimum, and the core shall be held together by bolts and clamping plates all of which shall be adequately insulated. The completed core shall be provided with lifting eyes to facilitate its removal from transformer tank and prevent movement during transport or service. All steel sections used for supporting the core are to be thoroughly sand blasted after cutting, drilling and welding.

The core shall be protected against corrosion by a resin or special varnish coat, thick enough to give adequate protection.

7.5 **Winding and Insulation Level:**

All windings shall be made of high conductivity conductors of best quality and shall be fully insulated to IEC 60076-11, Insulation Level List 2, Table V, and for a system highest voltage of 4.0 KV. The insulation shall be Class "F" to British Standard Specification No. 2757.

7.6 **HV side Cu. Wire. LV Side Cu. wire / foil / sheet.**

Both HV and LV windings shall be cast under vacuum into moulds with reinforced epoxy resin. The windings shall be suitable for operation under the Kuwait climatic conditions where the humidity may reach as high as 100%. Tenderers not complying with above requirement will be rejected.

It shall also be possible to energize the transformer after long periods of storage or being dead without any need for drying.

The windings shall be non-flammable to a reasonable and practical degree, and shall be self-extinguishing. Partial Discharge values of the transformer (without enclosure) should be tested in accordance with IEC 60076 part II and the values thus tested should comply with Clause No. 22.5 of IEC. The successful tenderer shall submit evidence in the form of a test report to show that the guaranteed values are actually achieved. The transformers shall be protected against thermal overload by the use of two sensors embedded in L.T. windings; one for alarm and the other for tripping. The connections for these sensors must be brought out to a terminal block. The transformer is to be provided with the related relay. The relay is to be fixed in a separate box. This box is to be fixed on the housing with suitable connection from the LV cable end box with related terminal block. The power required for the relay operation is to be taken from the transformer LV cable End Box through a double pole (phase and neutral) MCB. The arrangement is to be complete to provide alarm signal or tripping signal to alarm contacts or tripping contacts at the terminal block.

All connections to the HV and LV windings inside the transformer housing shall be fully insulated.

The Copper Bars / cable connecting the HV winding together to make the delta connection shall be of electro-tinned copper.

7.7 **Off-Circuit Tapping:**

Off circuit tapping shall be provided on the center (both electrical and mechanical) of the HV windings. These shall be arranged as follows:

Normal Voltage, + 2.5%, - 2.5%, + 5%, – 5%

The transformer shall be capable of operation at its rated KVA without injury on any tapping and at any applied voltage which does not vary from the voltage for which the tapping is rated by more than +5%.

The tap changer is to be protected by a transparent dust proof box.

A caution plate that the tap changer is to be changed only after disconnecting the transformer from both HV and LV sides is to be fixed on the transformer housing on the access cover to the tap changer.

7.8 **Housing:**

The housing shall be constructed of hot-dip galvanized steel 3 mm. thick with the necessary reinforcing sections.
Suitable lifting lugs must be provided to enable the transformer to be lifted by means of an overhead crane and slings. Suitable lugs shall be provided on the housing to facilitate its removal.

The housing shall be provided with two suitably located earthing studs connected in a ring though 3x25 mm. Tinned Copper strip. All transformers shall be fitted with jacking lugs located at a suitable height from ground level.

The housing shall provide protection against contact with any live part, and also to protect the equipment against mechanical damage. Appropriate class or degree of protection shall be clearly stated in the offer. The housing shall be finished both internally and externally with powder coating paint.

The housing shall be well ventilated by having suitable perforations in the bottom plate and on the upper parts of the sides.

The construction of the housing shall be such that the accumulation of fine sand and dust is avoided to a practical degree.
The housing shall have an easy access to the tap changer by means of a removable cover especially when high voltage and low voltage cables are connected.

8. SPECIFICATION FOR PHOTOVOLTAIC SOLAR CABLE

1. The cable shall be two layer construction with a low smoke halogen-free, flame retardant and sunlight resistant cross-linked compound outer layer and halogen-free thermoset polyolefin inner layer.
2. Suitable for continuous operating temperature of 90ºC Wet or Dry.
3. UL listed as Sunlight resistant.
4. Vertical Flame performance: EN60332-1
5. Excellent UV and Ozone resistant
6. Suitable for wet, damp and humid locations.
7. Specially designed for excellent flexibility.
8. Compatible with all major connectors
9. Cold bend and impact : -10º to +90ºC.

Applicable Standards:

- TUV Certification 2 Pfg 1169/08.2007
- TUV listed as PV1-F, 1000V (60038697)
- UL listed as Type USE-2 or RHW-2: 600V (E76090)
- UL Standard 854: Standard for Safety for Service Entrance cables, Type USE-2 or RHW-2; 600V
- UL subject 4703: outline of investigation for Photovoltaic Wire, type PV 1000V
- IEC 60228: conductors of Insulated Conductors, Class 5
- ASTM B-33: Standard Specification for Tinned Soft or Annealed copper wire for electrical purposes.
- 90ºC temperature rating: Temperature index in excess of 120ºC
- RoHS Compliant.

9. MONITORING COMBINER BOX

Field Operation with maximum safety shall ensure with the following:

- Outdoor string combiner box listed according to UL1741
- Fuse per input (replaceable)
- IP65 degree of protection for outdoor installation suitable to Kuwait weather conditions

- Lightning protection (Surge Arrestor for each String and Surge arrestor for each Cabinet)
- Web based string performance monitoring
- Automatic self-testing of main components
- Communication to monitoring web server via RS485 or Ethernet
- Remote control of cabinets from web server
- Per string ground fault detection and automatic isolation.
- Warranty : 25 years

The solar module to be coated after installation with nano hydrophobic and antimicrobial with specifications that meet or exceed the following:

a) Nano scaled layers consist of polymerized SiO_2 molecules.
b) Ultra-thin clear protective layer that withstand large forces and pressure.
c) Protects and covers all solar module (metal profile, glass surface, silicone sealing).
d) Light transmission remains unchanged after the application.
e) Coating can only be removed abrasively.
f) Heavily reduce adhesion of dirt and easier removal of sand, dust, pollen, soot, etc.
g) Glazing of silicone to tighten the silicone joint between the glass and the metal.
h) Minimum 5 years warranty of the coating.
i) Chemical resistance range pH 2- pH 12
j) Coating thickness < 100 nm
k) Temperature resistance range -50 to 450 degrees

10. LIGHTNING PROTECTION SYSTEM:

The contractor shall design, supply and install lightning protection system for PV System according to latest British Standard. The design of the lightning protection system shall be done by manufacturer of lightning protection system taking into consideration of the soil resistancy of each site. Commissioning of the lightning protection system shall be done by the Manufacturer or by Specialist Company, for testing lightning protection system as per BS.

11.1 Joints:

Permanent joints shall be made by exothermic welding or by crimping. Detachable joints shall be bolted and stranded conductors at bolted joints shall be terminated in exothermically welded lugs.

Connections to electrical equipment shall be made at the earthing studs or bolts provided on the equipment by the manufacturer. When an earthing point is not provided the point and the method of connection shall be agreed with the local authorities.

Connections to metallic structures for earthing conductors and bonding conductors between electrically separate parts of a structure shall be direct exothermic welding or by bolting using earth boss welded to the structure.

Bolted joints in metallic structures including pipe work, which do not provide direct metallic contact shall be bridged by a bonding conductor.

11.2 **Selection Schedules for Reference Specifications**

Earthing & Bonding Components:

General:

Comply with work section general clauses and those detailed below. Supply earthing and bonding components as specified in section.

11.3 **Conductors:**

Type: Stranded soft drawn copper or solid tape copper
Application: Air terminals, earth conductors, bonding conductors.

Conductors for lightning protection system as per BSEN 62305 (Part III)

Horizontal air terminations –

Covering PVC where specified colour as specified as per BSEN 13601.

Self-supporting air terminations - reference

Conductors for earthing systems to BS 7430.

Reference Y80.2010C

Conductor joints

Lightning protection - as per BSEN 62305 (Part III)

Earthing systems

Tape fixing devices as per BSEN 62305 (Part III)

All Copper tape used for lightning protection shall be tended and covered by PVC.

11.4 Equipotential Bonds (as per BSEN 62305 (Part III):

Type

Application

Main equipotential bonds

Reference BSEN 62305

Supplementary equipotential bonds

Reference BSEN 62305

11.5 Earthing:

Type: Stranded soft drawn copper; solid tape copper; Solid copper bars

Application: Circuit Protective conductors, Main earth ring conductors;

Main earth terminals.

Circuit protective conductors

Reference BSEN 62305

Earthing clamps – BSEN 50164

Main Earth terminal busbars

Test links - BSEN 50164

Lugs/tags

Protective cable terminations

Protective conductor warning notices/labels

Reference

Main earth conductor - BSEN 50164

Earth bar label

11.6 Workmanship:

Clean earth distribution – BS 7430

Dissimilar metals – BSEN 50164

Tape joints (as per BSEN 62305 (Part III)

Copper – BSEN 50164

Aluminium – BSEN 50164

Stranded conductor joints - BSEN 50164

Protective cable terminations

Reference BSEN 50164

Earth electrodes

Reference BSEN 50164

11.7 **Testing and Commissioning of Electrical Services:**

General:

The testing and commissioning of the earthing system and lightning protection system shall be done by the manufacturer or Specialist Company approved by manufacturer for conducting the test. All test equipment shall be calibrated by International Test Laboratory.

Testing & Commissioning:

Incorporated equipment characteristics

Prospective short circuit current (I_P)

Reference BSEN 62305

Initial verification

Test equipment and consumables

Testing

BSEN 62305

Continuity of protective conductors

ac or dc – BSEN 62305

Earth fault loop impedance (ZS)

BSEN 62305

Settings and adjustments

Lightning protection – BSEN 62305

Calibration

Certification and reporting

Reference BSEN 62305

Completion Certifícate

Reference BSEN 62305

Workmanship:

Conductive parts – BSEN 62305
Phase sequence – BS7671
Cables

LV buried cables - reference BS7430

LV and HV buried cables – IEEE80

Conduit, trunking and ducting - reference BS7671

Identification - Electrical

General:

Comply with work section general clauses and those detailed below.

Labels and Notices:

Fit labels and notices as shown on contract drawings/schedules.

Labels and Notices Materials:

Fit labels and notices of specified materials as per specified standards.

Material (as per BSEN 50164 (Part III)

Fixing (as per BSEN 62305 (Part III)

Arrangement

Lettering and size of labels and notices

Conductor Arrangement:

Reference BSEN 62305

Schematic Diagrams:

Provide as installed schematic diagrams of earthing / lightning protection systems. Reference BSEN 62305

Special Purpose Earthing:

Provide as shown in drawings/schedules.

Reference BSEN 62305

Cable Identification:

Cable identification

Terminal marking and conductor identification

Underground cable identification

Cable conductor colour coding

Cable jointing and termination -

Cable sheath identification - internal

Cable sheath identification – external

Additional Safety Signs:

As required by BS 7671 and/or as specified.

Earth Rods

Earth rods shall consist of hard drawn copper from an approved manufacturer, with a diameter of not less than 16.0 mm. Each rod shall be threaded at both ends and internally threaded couplers provided to connect together adjacent lengths. Screwed driving heads and points shall be provided to prevent damage to rods while being driven into the ground.

Each electrode shall comprise of a number of lengths of rod, which are arranged to provide the required minimum resistance. Provide the calculation in accordance with BS7430 to determine the number of rods to be used.

Carry out soil tests in accordance with BS 1377 to establish soil electrical resistivity.

The main earth shall have an earth resistance not exceeding 0.5 Ohm.

Comply with clause reference BSEN 62305.

Earth electrode clamps: BSEN 50164

Earth electrode tank penetration seal: BSEN 62305

Earth electrode Inspection Covers and Test Links:

Provide each earth electrode with an inspection box, which shall be installed flush with the finished surface, with removable covers. The boxes and covers shall be constructed in concrete and the cover shall be permanently marked "Main Electrical Earth" to approval of the Engineer.

In the case of earth electrodes built under concrete structures the penetration shall be equipped with a purpose made tank double flange penetration seal.
Comply with BSEN 62305

Provide each earth electrode with an approved test link, in accordance with BSEN 62305.

Switchboard Earthing Bar

Every switchboard, panel board, distribution board, control panel, Motor Control Centre shall be equipped with a full length DISCONNECTING LINK earth bar sized to carry the maximum earth fault current. The protective conductors of the incoming main cable(s) and all outgoing circuits shall be connected to this earth bar and the enclosure metal work shall also be bonded to this bar.

Earthing (Circuit Protective) Conductors:

Earthing or protective conductors and bonding conductors shall comprise of PVC insulated stranded copper conductors in accordance with the specified standard. Earthing conductors direct buried in the ground shall be un-insulated. These conductors shall be sized in accordance with the relevant regulations and/or the performance requirements specified in this document and/or according to the drawings and schedules.

Comply with BS 7430, IEEE80
Earthing clamps – BSEN 62305

Additional Earthing Conductors:

Armoured cables and/or bus-bar trunking systems shall each be provided with a separate Earth continuity conductor, the cross sectional area of which must be at least 50% of the phase conductor cross-sectional area.

Protection against Earth Leakage Currents:

In addition to the requirements for earthing and bonding provision shall be made as shown in the drawings for protection and monitoring against earth leakage currents in accordance with BSEN 62305 – 4 and BS 7671 and MEW regulations.

Testing and Commissioning:

Test and commission the system in accordance with, BSEN 62305, BS 7430 and BS 7671 and as specified.

Record all test measurements in accordance with - reference BSEN 62305.

The Contractor shall carry out the necessary tests of soil resistivity at selected points to the engineers approval to determine the suitability or otherwise of a proposed position for a main earth terminal.

Continuity and earth resistance tests shall be undertaken to the satisfaction of the Engineer when the installation has been completed.

Quality Control:

Handle, store, and install all equipment and components of the earthing system in accordance with the manufacturer's recommendations and BS 7430, BS 7671, BSEN 62305.

Inspect all equipment and components on delivery, before fixing and after installation and reject and replace any, which are defective.

Note: 1. **Tenderer shall provide with his offer complete preliminary design of the earthing system and lightning protection system, technical specification, catalogues, otherwise the offer will be technically rejected.**

2. **Complete design calculation and drawing for earthing and lightning system shall be submitted within two months from signing the contract.**

12. METEOROLOGICAL STATIONS:

The contractor shall design, supply and install meteorological station to measure the following and send to the Load Management System:-

- Global horizontal irradiance
- Irradiance on plane of array
- Dry bulb temperature
- PV module temperature
- Humidity
- Wind speed and direction
- Precipitation / rainfall
- Dust fall

- All instruments used shall be UL approved list and used Kuwait minimum five (5) years and manufactured from USA or Europe.
- All required cables, electronic card, software, …etc. shall be provided by the contractor.
- The exact location for the meteorological station shall be determined at site.

13. PARTICULAR SPECIFICATIONS AND CONDITIONS

13.1 Scope of works of Photovoltaic Power System

Design – The design of the PV Power System shall be carried out by an International Consultant with following qualification: -

a) Consultant shall be from USA, UK, Europe, Japan, India and Korea.

b) Consultant of Design the photovoltaic power system project shall have minimum 10 years experience in the relevant field and the design shall be not less than 15 MW of PV power system in total in the last five (5) years.

c) The details of previous experience shall be submitted with the offer.

d) An ISO 9001 quality management system certified Consultant.

e) The Consultant must have agent in Kuwait.

f) Consultant Engineers must be available in Kuwait at the design. Supervision and commissioning stage.

13.2 **The design shall be including the following for preliminary and final design**: -

i) Design calculation for power generated by PV System in each month of an year and total power generated per year. The calculation shall be done by International approved software.

ii) Cable sizing calculation:

iii) Inverter

iv) Combiner Box

v) Load Management System with Power Optimization system and monitoring system.

vi) Lightning system (intenal and external) calculation

vii) Earthing sysem calculation

viii) Mounting system of PV Panel at roof of the shed taking in to consideration of civil calculation of the roof, the roof shall be designed to withstand live load, dead load, wind load, PV panels, …. etc.

ix) Precautiions shall be made to protect staff on the roof during installation and maintenance.

x) All required Electrical Installation to connect the PV Power System on each site to the existing electrical panel at each site as per MEW Specification and Regulations.

xi) Fire Safety and precaution as per international standard to prevent fire causing by PV System.

xii) Inverter in weatherproof enclosure for indoor and outdoor as per ‘item 12’.

xiii) All other required to complete the operation of PV system in a satisfactory condition.

13.3 The design shall consist of two parts; Preliminary design and Final design. Preliminary design shall be submitted along with tender submission and shall contain sufficient information to prove that the offered system shall ensure efficient power generation.

Preliminary design shall include PV Power System and all items as per per mentioned above. Ministry reserves its right to reject any offer not accompanied by the Preliminary design. Further, the Ministry reserves its right to instruct the tenderer to revise the preliminary design, if Ministry considers the design to be sub-standard. The Final Design with all relevant technical details shall be rechecked by Approved Third Party within Two months of signing the contract.

Supply, erect, connect, test and commission the PV Power System complete with PV panels, inverter, combiner boxes, Power energy optimizer for PV system, cables, earthing system, lightning and all other required equipment and materials, in accordance with the Final Design.

The final design shall be re-checked by approved Third Party. The contractor shall pay all the expenses for re-checking the design.

All required Electrical Installation for PV Power System.

All other works required to complete the PV Power System in a satisfactory operating condition.

Photovoltaic Performance and safety testing shall be done by the manufacturer's engineer under the supervision of approved Third Party Inspection Authority and MEW engineer according to the following standard: -

IEC 62446: 2009 – Grid connected PV systems

Minimum requirements for system documentation, commissioning, test, and inspection specifies the minimum requirements for PV system documentation, commissioning tests and inspections.

CE1 82-15 / NF EN 61724: Guidelines for measurement, data exchange and analysis.

CEI 82-11 / NF EN 61725: Analytical expression for daily solar profiles.

CEI 82-3 / NF EN 60904-3: Measurement principles for terrestrial photovoltaic (PV) solar devices with reference spectral irradiance data.

CEI 82-2 / NF EN 60904-2: Requirements for reference solar cells.

CEI 82-6 / NF EN 60904-6 : Requirements for reference solar modules.

In case of the failure of performance test or the power generated by PV System less than the specified in the Bill of Quantity, the Ministry has the right to reject the PV system without any obligation.

Guarantee maintenance for a period of Two years from the date mentioned in the Taking Over and Acceptance Certificate.

The contractor shall fullfill the following requirement of MEW for connecting solar power to ministry of electricity & water (MEW) GRID : -

1. The Contractor shall engage an international consulting firm for the design of the solar energy systems that has a minimum five (5) years of experience in the relevant field and designed not less than 10 MW of PV power systems in total in the last five (5) years.

2. The solar energy systems for grid connected systems shall be connected only at the Main Low Tension Panels of the Distribution Substations/Transformers, or for smaller projects at the Main Electrical Switch Boards.

3. Only one or two large sized inverters shall be located in the Air-conditioned Electrical Rooms of the Distribution Substation. A series of small sized inverters for solar energy system is not acceptable.

4. The detailed design drawings for the solar energy systems for grid connected systems shall be submitted for MEW approval.

5. All solar energy generation calculations and other electrical design calculations including calculations for connecting cables sizing for the solar energy systems shall be submitted detailing different design parameters.

6. The overall solar energy system of the project shall be summarized to include particulars like, Nos. of solar (PV) panels/modules, their sizes and capacities, details of inverters, available solar energy, etc. and submitted in excel sheets so as to obtain complete information on the solar energy system at a glance.

7. There shall be two circuits to disconnect the solar energy systems in case of grid power failure: -

   a) One circuit with the inverter.

   b) Second circuit with a separate control to disconnect the breaker available at the connection point of the Solar Power to the MEW Network.

   c) On availability of power supply, the circuit with the inverter shall be automatically connected with a time delay of 2 to 3 minutes and the breaker for the second circuit shall be automatically connected with a time delay of five (5) minutes.

8. The Protection System shall include a Power Quality Meter to monitor the quality of power generated and to disconnect the power supply in the events

of:

- Operating voltage is greater than 260 V phase to neutral.
- Operation voltage is less than 220V phase to neutral.
- Operating frequency is greater than 52 Hz.
- Operating frequency is less than 48 Hz.
- Total harmonic distortions exceeding 5%.

9. The solar energy systems shall be provided with necessary Intelligent Solar energy metering system for measuring the following and send data to load management system.

   a) Total Solar power (in KWH) generated from PV system.
   b) Total Solar Power (in KWH) export to MEW grid.
   c) Total Power import from MEW (in KWH).

10. The manufacturers of the PV Panels and the Inverters shall be from one of the approved manufacturers of the Ministry of Electricity & Water.
11. The testing and commissioning of the solar energy systems shall be done by the contractor through an accredited and approved third party specialized in PV Solar System and must be audited by MEW Engineer.
12. It is the Contractor who will be fully responsible for occurrences of any accidents during the operational life time of the solar energy system.
13. The contractor is also responsible for proper maintenance and operation of the solar energy system.
14. A yearly inspection shall be carried out by the contractor through an accredited third party inspector like, Lloyd's Register, Bureau Veritas, Vecto Inspection, Germanischer Lloyds or equally approved Third Party Inspector and Inspector's Certificate shall be provided to MEW.
15. The Contractor shall submit all final as-built drawings for the solar energy systems to MEW for approval and record purposes.
16. The contractor must supply, install, test and commission solar power parameters of the project at Subhan and transmitting it to control room at MEW Head Quarter's basement (South Surra).
17. The provided monitoring and system controller has to run on BACKnet protocol with a gateway that allows BACKnet/IP communication. The contractor is responsible to establish the internet connection for the system with access permissions to allow communication of data transferred over IP.

13.4 Site Location

As shown on site layout drawings and as mentioned in the specification.

13.5 Geographical Data & Climatic Data:

- Altitude: 55 m
- Latitude: 29.22º North
- Longitude: 47.98 º East.

13.5.1 Climatic Data:

Extreme recorded conditions

- Maximum sun radition temperature (black bulb temperature) in summer: 84ºC
- Maximum ambient dry bulb temperature in summer: 52 ºC
- Maximum relative humidity: 100% at 30 ºC
- Maximum ambient dry bulb temperature in winter: -3 ºC

13.5.2 Sand and dust storms

Violent sand and dust storms are common, and dust remains suspended in air even on comparatively still days. During dust storms, visibility may vary from average to nil.

13.5.3 Prevailing winds:

Normally northerly to northwesterly winds are predominate. The annual average speeds for coastal and interior areas are 3.7m/s (12ft/s) and 4.0m/s (13 ft/s) at 10m above ground surace. The maximum recorded wind speed during a storm is 36.0 m/s (118 ft/s).

13.5.4 Mean temperature at 90 cm below ground surface:

- Summer: 35 ºC
- Winter: 20 ºC

13.6 Solar Radiation Data

All tenderers shall use the same radiation data, to arrive at performance reduction and guaranteed system output, to enable MEW to do a realistic comparison of system output of various bidders. The recommended source of satellite derived solar

radiation data is Kuwait National Meteorological Network, under Kuwait Institute of scientific Research (KISR) (website: www.http:// kisr.edu.kw.) who can provide hourly satellite derived GHI and DNI data for the site. The proof of having used the above data for the design shall be furnished by the tenderer along with the offer. The data shall be for a period of one full year.

13.7 **System requirements**

13.7.1 The PV Power System shall supply power to match with the following Electrical Power Supply characteristics of Kuwait.

Voltage (3phase 4 wire):	400V+10% or – 6%.
Voltage (single phase):	230V+10% or – 6%.
Frequency:	50 HZ +4%.
Nuetral:	Solidly earthed.
Fault level	31MVA at 415 V.
Fault operation:	0.15s.

The PV Power system shall deliver expected power at AC at Main Switch Board at each site.

13.9 **Programme of Works**

The contractor shall submit a detailed Programme of Works within one month of signing the contract along with the main project programme. The programme shall use PERT and CPM charts, in order to ensure effective planning, scheduling and control of the project. The programme shall be updated at regular intervals, showing progress of the project, deviation from the original programme and corrective measures taken to make sure that the project is completed in time.

13.10 **Completion of Works**

After completion of all works in accordance with the Project specifications, approved working drawings and bill of quantity, contractor shall write to MEW stating that the project has been completed. Along with the letter, the contract shall submit 4 copies of Maintenance File containing “As Fitted” drawings, technical schedules, engineering catalogues, operation and maintenance instructions, of all equipment installed at site. Upon receiving the letter and the files, MEW shall constitute a Committee to inspect the Installation and to certify the completion of works. Outstanding remarks, if any, given by the committee shall be rectified by the contractor within two weeks of receiving such remarks from MEW. Erection and Handing over Certificate shall be issued on satisfactory completion of all remarks.

13.11 **Testing and Commissioning:**

After completion of all works, the contractor shall carry out necessary pre-commissioning tests/checks as recommended by the manufacturers of various equipment and witnessed by the commissioning engineer of the manufacturer of the PV panels. On completion of all such tests/checks, the PV power system shall be commissioned by the PV manufacturer's commissioning engineer under the supervision of Third Party Inspection Authority and MEW engineer. Hourly readings of various parameters shall be recorded. On satisfactory completion of commissioning of the system, the commissioning engineer shall issue a certificate to this effect.

13.12 **Reliability Test & Taking Over:**

After successful completion of commissioning, the system shall be operated by the contractor for a period of 30 days. At summer time cloudy and dusty days shall be excluded from the test period. The system shall run continuously without defects, break down or stopping. In case of any defect, breakdown or stopping, the test shall be repeated for an additional period, as directed by the engineer. Hourly readings shall be recorded on purpose made forms. On satisfactory completion of Reliability Tests, Taking Over and Acceptance Certificate shall be issued by the Ministry, indicating the date of commencement of Guarantee and Maintenance Period.

13.13 **Guarantee and Maintenance Period:**

Guarantee and maintenance period shall be Two years from the date mentioned in the Taking Over and Acceptance Certificate. During this period contractor shall be responsible for all maintenance works including PPM (Planned Preventive Maintenance) routines. All spare parts including consumable spares parts shall be provided by the contractor.

14. TRAINING:

The Contractor shall provide training to twelve (12) MEW engineers for a minimum period of two weeks at Kuwait. The training shall be conducted before the commencement of installation works of the PV system at the site. After completion of the training, the trainees will be associated with the project during installation as well as operation & maintenance (O&M) of the system during guarantee maintenance

period. All expenses of the training including materials shall be borne by the contractor. The instructor of the training shall be as following:

Items	Description
PV Systems	Instructor of PV System shall be from manufacturer.
Inverter	Instructor of Inverter shall be from manufacturer.
Load Management System	Instructor of Load Management system shall be from manufacturer.
Automatic Washing system	Instructor of Automatic Washing system shall be from manufacturer.

The venue of the training shall be in Five Star Hotel.

Detailed training programme at the premise of manufacturer and inside the Kuwait shall be submitted with the offer.

The training shall be split into 5 modules

- Introduction to PV System
- System Design of PV System
- System Installation
- System Operation
- System Maintenance

14.1 **Introduction to PV System:**

This module will familiarize the trainee with the general information of PV systems, their performance parameters and principles.

The training will include:

- Introduction to Photovoltaic (PV), Overview and Technology Context
- Solar Resource (daily and seasonal variations)
- Solar modules, panels and arrays, components
- Performance, module design and specifications
- Interconnections .
- Diodes and grounding
- Shading, dirt and damage
- Safety issues
- Racks, purpose, materials, design, mountings.

- Controllers (purpose, functions, electrical characteristics, adjustments, meters).
- Batteries (storage options, types, designs, characteristics, performance specifications).
- Battery safety issues (acid handling, H_2 production, need for ventilation, battery disposal issues).
- Inverter Types Functions and applications .
- Inverter Capacity and Efficiency .
- Specifics of the inverter type used in installation, safety and protection .
- PV wiring differences .
- Wiring types, sizes and sizing, ratings, losses, colors .
- Wiring schemes, terminations, connections, safety, fuses and grounding .
- Protections, safety disconnects, over current protection, lightning protection.

14.2 **System Design:**

- Design considerations, site selection, site assessment and installation planning.
- Design operating modes, automation, time of operation, switching needs.
- Determining the load.
- Design the system in compliance with all applicable building and electrical codes.
- Design the system with a minimum of electrical losses due to wiring, fuses, switches, and inverters, etc.
- Ensure the roof area or other installation site is capable of handling the desired system size / weight.
- Specify sunlight and weather resistant materials for all outdoor equipment.
- Locate the array to minimize shading from foliage, vent pipes, and adjacent structures.
- Ensure the design meets local utility interconnection requirement.

14.3 **System Installation:**

- Site selection, site assessment and installation planning .
- Safety review and construction safety requirements .
- Quantity survey and quality checks of materials and components .
- Tools and equipment .
- Practical installation exercise (Racks, wiring, controller, batteries, inverters, etc.
- System testing and performance checks .
- Final checks.

14.4 **System Operation:**

- Operational planning, anticipation of system demand, daily, weekly and seasonal .
- Weather observations, anticipation of solar contribution, seasonal aspects .
- Design operating modes, automation, time of operation, switching needs .
- System parameters, meters, displays, data loggers.
- Monitoring, recording and logging of operational data.
- Operational limits for battery storage, effect of deep discharge.
- Safety issues, emergency disconnect.

14.5 **- System Maintenance:**

- Maintenance schedule, maintenance planning.
- Maintenance procedures for arrays, wiring, electronics.
- Maintenance requirements for batteries.
- Replacement of system components.
- Reports (daily, weekly, monthly, etc.).
- Fault finding, trouble shooting, operator discretion and communication with head office.

Manual cleaning of PV system shall be done every 10 days or after sand storm, in addition to Automatic cleaning System.

14.6 **Training Material:**

Each trainee shall be supplied with the following:

- Student manuals.
- Course manuals.
- CD for all courses material.

15. SPARE PARTS FOR PV POWER SYSTEM

The Contractor shall supply spare parts to MEW Store as mentioned in the BOQ.

In addition to the above items, the Contractor shall submit a list of spare parts required for maintenance of the PV Power System for the period of 10 years as recommended by the Manufacturers of the various equipment used in the Power System within one year of signing the contract. This list shall be used by the Owner for ordering spare parts in future.

16. PREQUALIFIED MANUFACTURERS:

16.1 PV Module manufacturers:

16.1.1 **List of Approved PV Module Manufacturers**

MEW has prequalified the following PV Manufacturers**:**

SL NO.	NAME OF THE MANUFACTURER	LOCATION OF PLANT
1	KYOCERA SOLAR Inc	USA/Japan
2	Mitsubishi Electric Corporation	Japan
3	Q-Cell SE	Germany
4	Sanyo Electric Co.	USA / Japan
5	Schott Solar	Germany / USA
6	Sharp Corporation	Japan, USA, U.K.
7	SOLON SE	Germany
8	BP SOLAR	USA, SPAIN, & AUSTRALIA
9	Canadian Solar Inc.	Canada, USA, Spain, Japan & Germany
10	Sun Tech Power	USA, Japan
11	SunWize Technologies, Inc.	USA
12	Centro Solar AG	Germany
13	Isofoton S.A	Spain
14	First Solar	USA
15	Trina Solar Ltd.	China
16	SunPower	USA
17	Yingli Green Energy	China
14	Equal and approved as per the attached Pre-qualification Form.	

Other manufacturers not listed above can be considered to be included in the list, provided that: -

The proposed manufacturer shall fulfill all the conditions for pre-qualification.

Tenderers shall fill up the pre-qualification form in all respects and submit to MEW through CTC before the Pre-Tender meeting. Any request, for enlisting a new manufacturer, received after the pre-tender meeting shall be rejected.

16.1.2 **PRE-QUALIFICATION FORM FOR PV MANUFACTURERS**

Name of Company	Years of Experience in manufacturing PV modules	Current Capacity **MW/Year**	Plant Location	R&D Facilities (Yes/No)	R&D Facilities with Full address	R&D Budget (Last Financial Year)	Recycling Facility (Yes/No)
1	2	3	4	5	6	7	8

Details to be filled in the columns and conditions for pre-qualification of PV Module manufacturers

1. Company's Full name, HQ address, web site etc.
2. Number of years of experience in manufacturing PV modules with the date of establishing manufacturing plant and commencing production (not the date of establishment of the Company) Minimum required 20 years.
3. Production capacity of each plant in MW/Year. Minimum required capacity 50 MW/Year.
4. Full address of manufacturing Plant.
5. Indicate whether the company has R & D facility. R &D is a must for pre-qualification.
6. Indicate whether the Company has R&D facility. R&D facility is a must for pre-qualification.
7. Give the full address of the R&D facility.
8. Give the last fiscal budget allocated for R&D.
9. Indicate whether the company has a "Module Collection and Recycling Program" through which the PV modules after the end of their useful life are recycled into new products including new PV modules. This requirement is a must for pre-qualification.

General Notes:

1) All information requested above must be provided with supporting documents and Annual Reports of the Company for the past 5 years.

2) Applicants shall meet the minimum requirements given at items 2, 3, 4, 5 and 8 in order to be considered for qualification.

16.2 **INVERTER MANUFACTURERS**

16.2.1 **LIST OF APPROVED INVERTER MANUFACTURERS**

MEW has prequalified the following Inverter manufacturers:-

SL. NO.	NAME OF THE MANUFACTURER	LOCATION OF PLANT
1	MITSUBISHI ELECTRIC CORPORATION	JAPAN
2	SIEMENS AG	GERMANY
3	HITACHI LTD.	JAPAN
4	SOLECTRIA RENEWABLES LLC	USA
5	SMA SOLAR TECHNOLOGY AG	GERMANY
6	CONVERTEAM	FRANCE
7	EQUAL AND APPROVED AS PER THE ATTACHED PRE-QUALIFICATION FORM.	

Other manufacturers not listed above can be considered to be included in the list, provided that: -

The proposed manufacturer shall fulfill all the conditions for pre-qualification.

Tenderers shall fill up the pre-qualification form in all respects and submit to MEW through CTC before the Pre-Tender meeting. Any request, for enlisting a new manufacturer, received after the pre-tender meeting shall be rejected.

16.2.2 PRE-QUALIFICATION FORM FOR INVERTER MANUFACTURERS

Name of Company	Years of Experience in manufacturing Inverters	Plant Location	Certification	R&D Facilities (Yes/No)	R&D Facilities with Full address	R&D Budget (Last Financial Year)
1	2	3	4	5	6	7

Details to be filled in the columns and conditions for pre-qualification of Inverter manufacturers

1. Company's Full name, HQ address, web site etc.
2. Number of years of experience in manufacturing PV Inverters with the date of establishing manufacturing plant and commencing production (not the date of establishment of the Company) Minimum required 20 years.
3. Certification requirement: ISO 9001 & ISO 14001 with UL listing.
4. Full address of manufacturing Plant.
5. Indicate whether the company has R&D facility. R&D is a must for pre-qualification.
6. Give the full address of the R&D facility.
7. Give the last fiscal budget allocated for R&D.

General Notes:

1. All information requested above must be provided with supporting documents and Annual Reports of the Company for the past 5 years.
2. Applicants shall meet the minimum requirements given at items 2, 3 and 5 in order to be considered for qualification.

17. COMMISSIONING AND TESTING:

The following equipment shall be commissioned by manufacturer's engineers.

1. PV power system including: Inverter, PV Panels, Combiner Box, Intelligent Solar Energy metering system, …etc.
2. Earthing system
3. Lightning system
4. Load Management system

18. THIRD PARTY INSPECTION AUTHORITY FOR PV SYSTEM & ALL EQUIPMENT FOR THE WHOLE PROJECT

The contractor should propose at least three Third Party Authorities for any required inspection to be conducted on the project as per the bill of the quantities, and MEW has the right to select the appropriate from the proposed list on every time the test to be done.

LIST OF APPROVED THIRD PARTY INSPECTION AUTHORITY FOR PV SYSTEM, LOAD MANAGEMENT SYSTEM, LIGHT FITTING, ELEVATOR …ETC.

SL. NO.	ORGANIZATION	FULL NAME
1	LR	LLOYD'S Register
2	ABS	American Bureau of Shipping
3	TUV	Rhenish West Falischer Technicher Uberwachunges Veren
4	DNV	Det Norske Veritas
5	BV	Bureau Veritas
6	GL	Germanischer Lloyd
7	RSA	Royal Sun Alliance
8	HSB	Hartford Steam Boiler
9	SGS	Societe General du-Service

19. CIVIL AND BUILDERS' WORKS:

The Contractor shall be responsible for all builders works associated with laying electrical cable, control cables, solar system cables, Fire alarm cables, Computer network cable, Load management System and BMS cables, Telephone cables, CCTV Cable and other electrical installation under this contract such as digging and excavation, constructing hand hole, cable trenches, manhole complete with manhole cover, dismantling false ceiling and reinstallation, provide new false ceiling if necessary, cable ducts for feeding cable back filling and finishing to the satisfaction of the engineer. The routing and locating of electrical service shall be in accordance with working drawing(s) duly approved by the engineer.

19.1 Should any obstruction be discovered while excavating existing premises for the purposes of intended installation work, it will be the responsibility of the contractor to re-route and re-located his installation work or the obstructing services after prior approval by the engineer.

19.2 All outdoor Power Cables or solar cables should run in 150mm U.P.V.C. concrete incased ducts as a minimum and manholes should be provided each 15 meter as maximum and at cable bends.

19.3 All outdoor Low voltage current (Data, CCTV, etc…) cables should run in 4-Way 100mm U.P.V.C. concrete incased ducts as a minimum and manholes should be provided each 30 meter as maximum and at cable bends.

19.4 All manholes for power cable shall be from reinforced concrete (K350) complete with heavy duty cast iron cover and shall have waterproofing membrane around the walls and below the floor slab, and shall be suitable size (1m x 1m x 1m, 2m x 2m x 2m, 1.5m x 1.5m x 1.5m)

Size	**Wall thickness (cm)**
1m x 1m x 1m	30
1.5m x 1.5m x 1.5m	35

Roof slab thickness shall be minimum 30 cm.

Roof reinforcement shall be 16mm dia @ 150mm c/c at bottom and 12mm dia @200mm c/c at top.

Wall reinforcement shall be 14mm @150mm c/c both direction.

Floor reinforcement shall be 14mm @ 150mm c/c both direction.

10cm blinding concrete (N150) shall be laid below the Floor slab.

This reinforcement is for guidance only and the contractor has to submit structural design for the M.H. before construction.

19.5 The price of builders' work includes modifying the size of electrical rooms, mechanical room to suit the size of the switchboards, without extra time or money.

19.6 The tenderer is required to visit the site of work under the contract and thoroughly investigate the existing conditions and fully account for all such works. Claims additional payment on account of such work overlooked by the tenderer at the time of pricing the tender shall not be entertained.

20. LOAD MANAGEMENT SYSTEM

Description:

The Load Management System shall monitor and control the various parameters of the PV power systems at various sites and shall send the data to the Control Room at MEW Headquarter building control room.

The Load Management System shall be a flexible system which is configurable to user specifics. It must support large range of features which enable the integration, monitoring and control of all photovoltaic system.

The integration of all systems shall be achieved through software programs, electronic components, hardware packaging and communication network through LAN IP and WLAN IP.

Scope of work:

Design, supply, install, label, test, commission, maintain and document Load Management System to cover whole project. Preliminary design of all system components situated within the container shall be submitted with the offer.

Quality Assurance:

A. **Applicable Standards**:

1) IEC 870-5-101
2) IEC 870-5-104
3) Other equivalent International Standards.

B. **Acceptable Manufacturers:**

All ISO 9001 and ISO 14001 certified Manufacturers, whose products have been in use for at least 10 years in Kuwait and shall be in the list of approved manufacturers of MEW. A valid certificate must be included in the tender document.

Submittals:

- Product data – Submit manufacturer's specifications, performance data, installation and maintenance instructions.
- Fill up the relevant Technical Schedule.

<u>Product</u> – Load Management System:

Description:

The Load Management System shall monitor the following parameters of all services in the project at different locations and send the data to the control room at of solar system at MEW Headquarter.

The following parameters must be monitored as minimum:

a) Array Voltage DC
b) Grid voltage AC
c) Array current DC
d) Grid (injected) current AC
e) Array Power DC
f) Grid (injected) Power AC
g) Module temperature
h) Ambient temperature
i) Solar radiation
j) Ambient humidity
k) Daily/monthly solar insolation
l) Daily / monthly/ yearly power generation from PV system.
m) Fault diagnosis
n) Alarms for various faults
o) Door open alarm for inverter enclosure.
p) Automatic washing system for PV Panel.
q) Lift inside stores.
r) Meteorological system
s) IP CCTV for monitoring and security.

System components:

The system shall consist of the following:

A. Automation controller: Local monitoring and control unit inside the inverter with controller and LCD touch panel with minimum 9” mounted on the inverter for system accessibility and control.

B. Communication network module: Local control station at each site to collect the data from all inverters and send to Control room at MEW HQ, through gateway (internet / GSM / telephone line etc.).

C. Local control room at each location shall consist of the following equipment:

i. Server to control and monitor PV Power system. The system shall have the capacity to store all the data for a period of Ten years and should meet or exceed the following specifications:

- Mothers board: Intel
- Motherboard FSB: ≥ 1GHz
- Number of CPUs: ≥ 2, ≥ 8 core
- CPU speed: ≥ 3.0Ghz
- CPU word length: 64 bits
- Cache memory: ≥ 8MB per core
- RAM capacity: ≥ 64GB DDR3 SDRAM
- RAM speed: ≥ 1333 MHz
- RAM expansion slots: ≥ 16 slots
- Disk storage: ≥ 10TB 15K rpm SAS 6Gpbs, hot plug, ≥ 8 bays
- RAID configuration: RAID 0-6
- Network interface: Dual 10Gb embedded Gigabit Ethernet card
- Monitor: 21" LED HD wide monitor
- Graphic card: ≥ 1GB
- Sound card: Integrated sound card
- Optical drive: Internal SATA interface, ≥ 24xDVD±RW
- USB ports: ≥ 3 ports 2.0
- Expansion slots: ≥ 4 PCIe G2 slots
- Power supply: Dual, hot plug redundant power supply (1+1) ≥ 750W
- Accessories: Optical mouse, Arabic Qwerty keyboard, 19" LED DH monitor
- Rack rails: Sliding rails with cable management arm

- Operating system Windows based.

ii. Laser color printer with the following specifications:

Color Laser Printer A4 Size (Network): New, original & Branded only with 3 years onsite comprehensive warranty. The printer's technical specification shall meet or exceed the following as minimum:

- Print technology: Laser
- Print speed (Black): Up to 20 ppm
- Print speed (Color): Up to 20 ppm
- First page out (Black): ≥ As fast as 9.5 seconds
- First page out (Color): ≥ As fast as 9.5 seconds
- Print resolution (Black): 600 x 600 dpi
- Print resolution (Color): 600 x 600 dpi
- Network: USB 2.0, gigabit Ethernet 10/100/1000 Mbps

iii UPS: 5 kVA as minimum to operate the system in the container for 6 hours, in case of power outage.

D. Passive network: LAN network of CAT6A /F/UTP copper cable (100 Ohms, LSZH jacket), floor boxes, outlets, RJ45 faceplates. UTP Cat6A patch cords, free standing server cabinet with all required accessories (power supplies, cable management, fans, power distribution etc.), 2 core multimode (OM3) fiber optic cables for IP cameras connection.

•

E. Active Network: 8 port 10/100/1000 10GBase stackable managed switch.

System features:

The Software features actual screen shots have to be provided showing the required features. Features supported must include the following as minimum:

A. **Access:**

- Access to data shall be global with capability of user profile and role management and access right management, such that users can access data, history, point detail displays, etc. for data points with customized user privileges.

- The system shall have the facility for accessing from any browser (Web enabled) by authorized person with security password.

- The load management system shall be accessed locally from the site server where **all** data points activated on the server to be linked to MEW HW control for the purpose of integration. The license should also allow multi workstations access with full software features and capabilities.

B. **Security/Filtering:**

It shall be possible to nominate sets of points to be accessed on a server-by-server and user-by-user basis. The mechanism shall be the same as the mechanism to control individual operator and workstation access to data for single server system.

The system has to be backed up with scheduled periods to insure data loss prevention and prevent data corruption with multiple periodic backups. Backups to be restored to any specific date in case of database corruption.

C. **Alarms /Messages:**

- Operators and workstations must be able to see events and alarms from any workstations or Web access to any application parameter with alarm viewer (security, maintenance, remote diagnostics, etc.).
- All alarms shall appear in the alarm list with specified priority and stored in central database. Each Alarm message should include shortcut to the relevant graphical system view.
- It shall not be necessary to configure alarms more than once, regardless of the number of users accessing the data.

- Having the system running with the ability to route alarms to user defined emails and sms.

D. **Trending:**

It shall be possible to configure real time and historical trends. It shall not be necessary to configure more than one point for each data value or signal, regardless of the number of users accessing the data.

The graphical trend must have the ability for customizes user parameters of graph plotting (time scale, parameter scale, periods start and end configuration, etc).

E. **Graphics / Reports / Applications**:

The system has to provide graphics and reports in record forms and accessed from anywhere. The reporting and plotting features has to be for both present live data and historical date. Customized reporting capabilities are a must where reporting criteria can be modified as per user needs (selected data points, periods, values filtering, value setting, etc).

F. **Interface:**

All systems features must be within the same graphical user interface for monitoring and control. The software can be installed on unlimited number of remote workstations through LAN IP providing all system features.

Integration and Web enabled technology:

- The information in Load Management System server must be available at internet through secure web access which supports simultaneous access of unlimited users with no required software installation via Web Access.

- The Load Management System should be web based technology and use IT Security strategies (firewalls, VPN) to interface with the existing Load Management System located at the main office of MEW for monitoring and collecting all measured data and trend points of the solar system to be present at MEW HQ control room solar server.

- The Load Management System controller **must** use standard communication protocols to insure full integration and live data accessibility between project load management system and existing system at MEW HQ control room.

- The Load Management System controller should provide gateway web access permissions for Third Party controller at MEW Head Quarter which operates with

BACnet/IP communications. In addition of providing extension module for third party communication for full communication and integration.

- Full database integration between system database and MEW HQ Oracle/SQL database for live data uploading to MEW power server. The project database has to be linked to MEW power server database with customized data points.

Installation

- The installation shall be carried out according to manufacturer's Installation and Safety Instructions, supervised by manufacturer's Specialist. The system shall be installed by specialist sub-contractor approved by MEW for SCADA works.
- The bid must include a diagram illustrating wiring to Photovoltaic system identifying each component, manufacturer and model number.
- The license of Load Management System application has to be permanent to show exact number of points to be measured (virtual and actual) and how many free points / parameters available for future growth.
- Real life simulation data has to be provided to test system prior to operating system. In case of inability to provide real life simulation data, a demo version of the software has to be provided prior to accepting it for the purpose of assessing the software features and capabilities.

Washing system controller:

1) Supplied by manufacturer of the washing system complete with all control valves. All control valves exposed to sun shall withstand the harsh weaker conditions of Kuwait.
2) Controller must have manual and automatic control.
3) Controller with PLC and screen for system status.
4) Historical data to be stored in a non-volatile memory and reports to be retrieved with user defined settings.
5) The software has the capabilities for historical logs and data records retrieving.
6) Integrating the automatic washing system with the load management system at the project for monitor data points and controls all data points.

7) System commissioning and testing to be with the presence of the manufacturer engineer.
8) All system components must of UL approved list.
9) The system to be with supplied with smart meter for water consumption.

Approved manufacturers of Load Management System shall be of the following:

SIEMENS – GERMANY
ABB – ITALY
HONEYWELL – USA
SCHNEIDER – FRANCE
JOHNSON CONTROL – USA
TOSHIBA – JAPAN

21. OPTIMUM SOLAR ENERGY FOR PV SYSTEM

To generate maximum energy Yield, the modules get smarter by connect each module to a power optimizer and shall be connected with load management system.

The Specification of power optimizer:

- Efficiency: >99%.
- Independent Optimization Technology.
- Minimum String length as per manufacturer's recommendation.
- Maximum String length as per manufacturer's recommendation.
- Monitoring: the module performance is display on a virtual site map in the Monitoring Portal.

Concept of Operation for Power Optimizer:

- Each Module always operates in the optimum.
- Weaker Modules do not affect the strong one.

- Modules can be mounted in multiple orientations and tiles.
- Strings can be unequal lengths and with different module capacities.
- The possibility to know exactly how much each individual module generate.
- PV System Module Mismatch.
- MPP Tracking Per module or Maximum power harvesting from each module.
- Partially Shaded areas also produce energy.
- Power Optimizer automatically shut down when inverter is off or disconnected.
- Warranty : 25 Years

24. **THE WEATHER-PROOF ENCLOSURE:**

The metal weatherproof enclosure shall be IP 65 and manufactured according IEE 529 and the test certificate from International laboratory shall be provided. The metal weatherproof enclosure shall be provided with the following:

(1) Earth terminal

(2) Neutral link

(3) Both externally and internally protected with polyester epoxy resin or equal.

(4) Recessed bottom cable gland.

(5) Locking systems, hinges and Gaskets.

5.1 Swing handles system for Outdoor weather-proof Cabinets / Enclosures

5-1 A. **Swing Handle System**

Standard:	IEC 62208, 90° turn.
Material:	Stainless Steel
Protection class:	IP 65
Warranty:	5 years,

Approved Manufacturers: SIEMENS, ABB, SCHNEIDER GENERAL ELECTRIC and EMKA.

5-1B. **Hinges**

Standard:	IEC 62208
Material:	Stainless Steel or
	Zinc Die Cast with Powder Coating.

Warranty: 5 years.

Approved suppliers: EMKA, SIEMENS, ABB, SCHNEIDER, GENERAL ELECTIC

5-1C**. Gaskets**

Standard: IEC 62208

Tolerances: According to DIN ISO 3302-1 E2

Material: EPDM rubber {ethylene propylene diene Monomer (M-Class) rubber}

Supplier: DIN ISO 9001:2000 and ISO 14001:2004
RoHS Compliant.

Warranty: 5 years.

25. **LABEL OF EQUIPMENT**

Substantial brass or stainless steel rating plates shall be provided on each equipment (i.e. inverter, PV panel, Automatic Washing system, Power factor correction, UPS, MLTB, MSB, Load Management System) giving the following information as a minimum.

- Manufacturer's name and country of origin.
- Serial number and type/model.
- Date of manufacture.
- Rated voltage in volts (V)
- Rated frequency in hertz (Hz)
- Minimum and maximum ambient temperatures in degree Celsius (ºC)
- Degree of protection
- Short circuit withstand strength in Amperes (A)
- Guarantee period.
- Any equipment without label shall be rejected.

For each submittal of equipment or material, the contractor shall submit compliance statement to prove that the equipment or material comply with specifications.

Cable Tags for Power and Control cable

Cable tags shall be made out of 2mm thick aluminium sheets. Each tag shall be 2" in dia or 3"x3" square with one hole of 2.5mm dia, 6mm below the periphery, or as approved by MEW Engineer. Cable designations are to be punched with letter / number punches and the tags are to be tied to cables with piano wires of approve quality & size. Tags shall be tied inside the panels beyond the glanding as well as above the gland at cable entries. Along trays tags are to be tied at all bends. On straight lengths, tags shall be provided at every 10 meters.

PERFORMANCE GUARANTEE (PG) TEST

The Performance Guarantee will be conducted at Site by the Contractor in presence of MEW Engineer as per IEC 61724. The PG test procedure needs to be submitted by contractor after the award of contract for review and finalization. The acceptance test should have binding on both the parties of the Contract to determine compliance of the equipment with the functional guarantee. Any special equipment, instrumentation tools and tackles required for the successful completion of the Performance Guarantee Test must be provided by the Contractor free of cost.

The procedure for PG demonstration test shall be as follows:

1. A calibrated Pyranometer for GHI measurement on Horizontal surface and a Reference Cell should be installed on collector plane by the Contractor as a part of Weather monitoring station at the location mutually agreed by Contractor and MEW Engineer . The test report for the calibration shall be submitted by the Contractor for approval.
2. Actual energy exported from the plants supplied by the Contractor shall be noted for three consecutive months. For this purpose, the net energy exported at the LV side.
3. This measured value of energy at step-2 shall be compared with Generation guaranteed for the PG test.
4. Generation for a month is the quoted generation by the contractor in the Generation Guarantee with actual average solar radiation measured by the calibrated Pyranometer and Reference cell for three months at step-1.

Following factors shall be considered for computing the Generation

i. Generation loss due to grid outage. The measured global solar radiation of the period of the outage of the power evacuation system shall be excluded to calculate average global solar radiation for the period of PG test.

ii. If Contractor is not able to demonstrate PG test during these three (03) months he will be given one more chance to demonstrate the PG test. In that case the steps for PG test shall be repeated again as above.

27. COMPLIANCE

By signing the contract with Ministry of Electricity & Water, the successful contractor shall be considered to be in full understanding and agreement with the full content of this tender document and its specifications (Arabic text, drawings and all Chapters). In case the tenderer has any reservation, disagreement or deviation-whatsoever- from this document, he should clearly indicate so by filling separate tables (non-compliance schedules) originated by him and divided in columns for. Chapter No., Page No., Item / Article No. and reasons of non-compliance. These tables shall be duly stamped, signed by the tenderer and submit along with the offer.

The tenderer is further required to fill, sign and stamp a compliance statement confirming compliance with key design parameters attached to this specification. The failure to comply will result in the automatic disqualification of his offer.

28. SOLAR CAR PARK SPECIFICATION

Car park must be designed in such manner that the parking space is fully utilized while largest possible roof surface areas are leveraged for maximum energy yield. Should be compatible with all PV Modules types and sizes. Should be compatible with all desired alignment or module inclination. Materials must be from Aluminum with Stainless Steel Fasteners, durable and corrosion free. Should be equipped with automatic washing system, cable routing system and combiner box fasteners. Warranty 10 years.

The car parking-type structures needs to be selected from Schletter, or equivalent which is aesthetically acceptable, and structure should be manufactured in Japan, Germany, or

USA. Care should be taken during designing such that water dripping as a result of cleaning modules or rainfall should not fall on vehicles parked below. The mounting structures shall be designed to sustain wind loading of up to 160 km/h, shall comply with ISO 657 and shall be anodized aluminum sections or profiles used for the structure. The entire structure, including the array, shall be earthed to an independent earth pit with redundant paths. The fasteners shall be made of SS304 and should comply with the appropriate standard. The array structure shall be designed in such a way that it occupies minimum space without sacrificing the output from PV panels at the same time. The structure shall be designed for easy replacement of any module. Moreover, the carport structure design should allow for safe and easy parking of vehicles, keeping in mind the various sizes of vehicles in Kuwait. The Contractor should submit the module mounting structure design and its load-bearing calculation results for approval.

1 row vehicle arrangement (1 vehicle parking spot) minimum depth 6 meter

2 row vehicle arrangement (4 vehicle parking spots) minimum depth 13.5 meter

Clearance Height minimum 3-meter.

Width for each car 3.50 metre.

The lower height of the Carpark can be modified upon client request.

Foundations design must be carried out by Car park structure manufacturer.

The contractor shall submit 3 (three) different designs for car park to the Ministry. Ministry has the right to choose one of them.

The manufacturer shall have ISO 9001, 14001 and 50001 certification and shall have at least 10 years' experience in manufacturing similar products.

Car parking shed with cantilever frame and structure roof with single columns in one row and without any additional column in front.

The new car shed arrangement and layout shall be as per Kuwait Municipality design criteria.

29. **SOLAR PARKING FOR EQUIPMENT**

Specification for Solar parking for equipment shall be the same specification of car parking, but the dimension for the solar parking equipment shall be as following:-

For one row equipment:-

- Length : 12 Meter

- Width: 7 meter
- Minimum Height: 5.5 meter

Solar equipment shed with cantilever frame and structure roof with single columns in one row without any additional column in front.

30. OPERATION AND MAINTENANCE

Compared to most other power generating technologies, PV plants have low maintenance and servicing requirements. However, proper maintenance of a PV plants is essential to optimize energy yield and maximize the life of the system.

Maintenance can be broken down as follows:

• **Scheduled or preventative maintenance –** Planned in advance and aimed at preventing faults from occurring, as well as keeping the plants operating at its optimum level.

• **Unscheduled maintenance –** Carried out in response to failures.

Suitably thorough scheduled maintenance should minimize the requirement for unscheduled maintenance although, inevitably, some failures still occur. A robust and well-planned approach to both scheduled and unscheduled maintenance is important.

Scheduled/Preventative Maintenance

The scheduling and frequency of preventative maintenance is dictated by a number of factors. These include the technology selected, environmental conditions of the site, warranty terms and seasonal variances. The scheduled maintenance is generally carried out at intervals planned in accordance with the manufacturers' recommendations, and as required by the equipment warranties. Scheduled maintenance should be conducted during early morning or evening.

Specific scheduled maintenance tasks are covered in the following sections.

Module Cleaning

Module cleaning shall be carried out automatically on pre-programmed schedule as recommended by the manufacturer of the automatic washing system.

Module Connection Integrity

Checking module connection integrity is important for systems that do not have string level monitoring. This is more likely for central inverter systems for which no string monitoring at the junction/combiner boxes has been designed. In such cases, faults within each string of modules may be difficult to detect. Therefore, the connections between

modules within each string should be checked periodically (this may include measuring the string current).

Junction or String Combiner Box

All junction boxes or string combiner boxes should be checked periodically for water ingress, dirt or dust accumulation and integrity of the connections within the boxes. Loose connections could affect the overall performance of the PV plants. Any accumulation of water, dirt or dust could cause corrosion or short circuit within the junction box. Where string level monitoring is not used, periodic checks on the integrity of the fuses in the junction boxes, combiner boxes and, in some cases, the module connection box should be conducted.

Hot Spots

Potential faults across the PV plants can often be detected through thermography. This technique helps identify weak and loose connections in junction boxes and inverter connections. It can also detect hot spots within inverter components and along strings of modules that are not performing as expected. Thermography should be conducted by a trained specialist using a thermographic camera.

Inverter Servicing

Generally, inverter faults are the most common cause of system downtime in PV power plants. Therefore, the scheduled maintenance of inverters should be treated as a centrally important part of the O&M strategy. The maintenance requirements of inverters vary with size, type and manufacturer. The specific requirements of any particular inverter should be confirmed by the manufacturer and used as the basis for planning the maintenance schedule.

The preventative maintenance for an inverter should, as a minimum, include:

- Visual inspections.
- Cleaning/replacing cooling fan filters.
- Removal of dust from electronic components.

- Tightening of any loose connections.
- Any additional analysis and diagnostics recommended by the manufacturer.

Structural Integrity

The module mounting assembly, cable conduits and any other structures built for the PV plants should be checked periodically for mechanical integrity and signs of corrosion. This will include an inspection of support structure foundations for evidence of erosion from water run-off.

Balance of Plants

The remaining systems within a PV power plants, including the monitoring and security system, auxiliary power supplies, and communication systems should be checked and serviced regularly. Communications systems within the PV power plants and to the power plants should be checked for signal strength and connection.

Typical PV Power Plants Maintenance Schedule

Sl.No.	Inspection	Actions required	Inspection Frequency
A	**Solar Modules**		
1	Dust deposition	Cleaning of modules	Once in a week
2	Module Junction box malfunction, visual inspection	Replace the Module in case of failure.	1 Month
3	Improper Module Cable Connectors	Replace the Cables / Connectors	1 Month
4	Delamination, discoloration leading to low output	Replace the Module	1 Month
5	Module Cracks	Replace the module	1 Month
B	**Solar Module Mounting Structure**		
	Inspection of Mounting Structure and Hardware	Check Fasteners - take remedial measures in case of issues. Check lugs of earthing conductors for corrosion – change as needed	3 Month
C	**SSM - String Monitoring Box**		
1	Check for Loose cable Termination	Tighten the connection	3 Months
2	Fuse Failed	Replace Fuse	3 Months
3	Surge Suppression Device	Check the connections - Replace if it is failed	3 Months
D	**SSM - String Monitoring Box (Out Put) Technical Parameters measured at >800 W/m²**		
1	Open Circuit Voltage (Voc)		3 Months
2	Output Current		3 Months
E	**Inverter (Input) Technical Parameters**		3 Months
1	DC Voltage @ Connection Point		3 Months

2	SSM Current @ Connection Point		3 Months
F	**Inverter**		
1	Loose cable Termination	Tighten the connection	6 months
2	Dust Deposition	Cleaning	Monthly
3	Cleaning of Air Filters	Cleaning	Monthly
5	Performance monitoring	Visual	Daily
6	Data Logging		Daily
7	Report preparation		Monthly
G	**Inverter (Out Put) Technical Parameters**		
1	Output Voltage		3 Months
2	Current		3 Months
3	Frequency		3 Months
4	Output Power		3 Months
H	**LV Panel**		
1	Loose cable Termination	Tighten the connection	6 months
2	Schedule maintenance as indicated by LV Panel Supplier		
3	Dust Deposition	Cleaning	Monthly
4	Performance monitoring		Daily
J	**LV Panel (Out Put) Technical Parameters**		
1	Voltage		Monthly
2	Current		Monthly
3	Frequency		Monthly
K	**Transformer**		
1	Schedule maintenance as indicated by Transformer Supplier		
2	Dust Deposition	Cleaning	2 months
3	Performance monitoring		Daily

L	**Transformer (Out Put) Technical Parameters**		
1	Voltage		Monthly
2	Current		Monthly
3	Frequency		Monthly
M	**MV Panel**	Schedule maintenance as indicated by MV Panel Supplier	
1	Dust Deposition	Cleaning	2 months
2	Performance monitoring		Daily
N	**MV Panel (Out Put) Technical Parameters**		
1	Voltage		2 months
3	Frequency		2 months
O	**Emergency Break down**		**As and when**
P	**Spare parts**	Ensure availability of spare parts as required for the plants to run normally.	1 month
Q	Irradiance Meter cleaning	Cleaning with soft cloth	Daily
R	Cable (AC & DC)	Visual inspection	15 days
S	SCADA	Data Monitoring	Daily

All periodic maintenance & inspections shall be done as specified by the equipment manufacturers.

Unscheduled Maintenance

Unscheduled maintenance is carried out in response to failures. As such, the key parameter when considering unscheduled maintenance is diagnosis, speed of response and repair time. Although the shortest possible response is preferable for increasing energy yield, this should be balanced against the likely increased contractual costs of shorter response times.

The agreed response times should be clearly stated within the contract and will depend on the site location— and whether it is manned. Depending on the type of fault, an indicative response time may be within 12 hours.

The majority of unscheduled maintenance issues are related to the inverters. This can be attributed to their complex internal electronics, which are under constant operation. Depending on the nature of the fault, it may be possible to rectify the failure remotely – this option is clearly preferable if possible.

Other common unscheduled maintenance requirements include:

- Tightening cable connections that have loosened.
- Replacing blown fuses.
- Repairing lightning damage.
- Repairing equipment damaged by intruders or during module cleaning.
- Rectifying SCADA faults.
- Repairing mounting structure faults.

The contractual aspects of unscheduled O&M are described in more detail below.

Spare Parts should be available at site during the operation and maintenance period:

In order to facilitate a rapid response, a suitably stocked spares inventory is essential. The numbers of spares required will depend on the size of the plants and site-specific parameters. Adequate supplies of the following components should be held:

- Mounting structure pieces.
- Junction/combiner boxes.
- Fuses.
- DC and AC cabling components.
- Communications equipment.
- Modules (in case of module damage).
- Spare inverters (if string inverters are being used).

It is important that spares stock levels are maintained. Therefore, when the contractor uses some spares he should replenish the stocks as soon as possible. This arrangement will reduce the time gap between the identification of the fault and replacement of the nonoperational component. This can be of particular relevance for remote locations with poor accessibility and adverse weather conditions. Consultation with manufacturers to

detail the spare parts inventory, based upon estimated component lifetimes and failure rates, is recommended.

Performance Monitoring, Evaluation and Optimization

To optimize system performance, there is a need to ensure that the plants components function efficiently throughout the lifetime of the plants. Continuous monitoring of PV systems is essential to maximize the availability and yield of the system.

The Load Management system is able to monitor the real-time efficiency and continuously compare it with the theoretical efficiency to assess if the system is operating optimally. This information can be used by the contractor to establish the general condition of the system and schedule urgent repair or maintenance activities such as cleaning.

Contractor's responsibility for Maintenance period

The contractor will be responsible for the operation and maintenance of the whole plants. This is likely to include:

- Modules and mounting frames.
- Inverters with all equipment inside the weatherproof enclosure.
- DC and AC cabling.
- String combiner or junction boxes.
- Load Management system, remote monitoring and communication systems.
- Site fencing and security system.
- Auxiliary power supply.
- Site access routes and internal site roads.
- Site building and containers.
- Maintenance of fire alarm and fire-fighting equipment.
- Automatic Washing system

Contractor Services and Obligations

The contract should list the services to be performed by the contractor. This list should be site-specific and include the following:

- Plants monitoring requirements.

- Scheduled maintenance requirements.
- Unscheduled maintenance requirements.
- Agreed targets (for example, response time or system availability).
- Reporting requirements (including performance, environmental, and health and safety reporting).

It should be stipulated that all maintenance tasks shall be performed by the contractor in such a way that their impact on the productivity of the system is minimal. In particular, the contract should stipulate that maintenance tasks should be kept to a minimum during the hours of sunlight.

31. **GUARANTEE MAINTENANCE:**

(i) The contractor shall provide for the maintenance period guarantee for all installed equipment and systems from the date of preliminary handing over which shall be given after successful completion of the reliability test.

(ii) If the successful contractor during the guarantee, maintenance and operation period fails to respond to any necessary repair called for by MEW within 12 hours after the contractor being notified by fax. The Ministry has the right to automatically activate the penalty of KD.200 (Two Hundred Kuwait Dinar) for every passed day after the notification. Furthermore, the ministry has the rights to execute the necessary repairs under full responsibility of the contractor and charge the contractor the cost of those repairs plus 10% administrative charges without accepting any claims from the contractor's side.

(iii) In addition to that the contractor shall provide maintenance management system software for the preventive maintenance of all systems and equipment in the project. The software be an enterprise licensed to MEW for a period of ten years. It should provide reporting mechanisms for system and equipment on periodic times (weekly, monthly and annually).

(iv) The preventive and routine maintenance schedules should be as recommended by the original equipment manufacturer and must be submitted to MEW for approval, including of periodic automatic and manual cleaning of PV panels.

(v) The contractor must provide a 24 hours on-call service for all installed system, for the period of maintenance starting from the date of preliminary handing over.

(vi) During the maintenance and guaranteed period, all consumable, non-consumable and spare parts used for maintenance shall be provided by the successful contractor free of charge.

(vii) During the maintenance and guaranteed period, all major or minor breakdown of the (supplied and installed) equipment shall be rectified by the contractor without any extra charges of labors or spare parts to MEW.

(viii) The successful tenderer has to arrange required technical Staff (Engineer, Foreman, and Technicians) 24 hours, 7 days a week (on call), for attending all maintenance works.

BUILDING MANAGEMENT SYSTEMS (BMS)

General

Drawings and general provisions of the Contract, including General and Supplementary Conditions.

The specification mentioned below are the minimum and guidelines to the contractor. However, the contractor should provide the latest configuration including the hardware and software available from the manufacturer at the time of approval such as advanced model, type, accuracy, etc.

Section Includes:

This Section includes supply, installation and testing of Building Management System.

SCOPE

All the designs shall be done by Manufacturer certified designer.

Wiring for cabling systems shall be carried out by a Specialist Contractor approved by the Engineer who has a design, installation staffs with at least 5 years' experience in Kuwait.

The BMS shall serve as global facility management system.

Point of Schedule for Electrical and Mechanical services should be looked on to find the equipment to be included in monitoring and controlling.

The following system shall be incorporated into the BMS

Mechanical Services:
Air Conditioning
Plumbing
Energy Management

Water leak detection system for all Raised Floors under main building (1st, 2nd and 3rd).

Electrical systems:

Generators and associated fuel systems

Automatic transfer switch

LT Panels, Main / Sub main Switchboards, Distribution Boards & Motor Control Centers (MCC)

Uninterrupted power supplies (UPS)

Maintenance Management of all Building Services equipment

Provisions for future Facility Management

Status only of devices and equipment related to Fire mode operation of the building. Fire Detection and Alarm system will operate independently, but it will be integrated to BMS to provide additional alarm status notification.

The BMS shall use IEEE 802.3 Standard Local Area Network (LAN) for communications

The architecture shall provide two levels of processing and control:

Central System Level: Enterprise Servers, Report Servers Workstations and Web Clients.

Automation Level: local microprocessor based units that can interact between them and communicate with the Central System Level providing local processing and storage. This level shall be as independent as possible in order to provide full functionalities even in the event of a failure of the Central System or an outage of communication links.

Multiple protocols: the BMS shall allow communications with a wide variety of proprietary and third party control devices utilizing off the shelf driver packages. It shall support BACnet, LON, Modbus, KNX, Java, XML, HTTP , CORBA IIOP ,and OPC standards for open system communications

The BMS contractor shall provide a points schedule showing each proposed connected point to the system. The points shall be arranged as schedules showing the points allocated on a plant by plant basis, the controller specification(s) selected, I/O capacity supplied and the spare I/O available for future use. Any points schedule supplied with this specification shall be considered as supporting information only. The BMS specialist shall be responsible for ensuring the correct allocation of points required for meeting the performance specification. The BMS contractor shall include a further schedule summarizing the field hardware and indicate the quantities, types, manufacturer and duties of the devices. Where a system comprises more than a single network, a diagram shall be supplied with the tender showing the lay-out of the LAN's and interconnections.

System Description:

In accordance to the scope of work, the system shall also provide a graphical, web-based, operator interface that allows for instant access to any system through a standard browser. The contractor must provide PC-based programming workstations, operator workstations and microcomputer controllers of modular design providing distributed processing capability, and allowing future expansion of both input/output points and processing control functions.

For this project, the system shall consist of the following components:

Administration and Programming Workstation(s): The BAS Contractor shall furnish (qty) Administration and Programming Workstation Computers as described in Part 2 of the specification. These workstations must be running the standard workstation software developed and tested by the manufacturer of the network

server controllers and the standalone controllers. No third party front-end workstation software will be acceptable. Workstations must conform to the B-OWS BACnet device profile.

Web-Based Operator Workstations: The BAS Contractor shall furnish licenses for (qty) concurrent web browser based users to the BAS system. Web-based users shall have access to all system points and graphics, shall be able to receive and acknowledge alarms, and shall be able to control set points and other parameters. All engineering work, such as trends, reports, graphics, etc. that are accomplished from the WorkStation shall be available for viewing through the web browser interface without additional changes. The web-based interface must conform to the B-OWS BACnet device profile. There will be no need for any additional computer based hardware to support the web-based user interface.

Ethernet-based Network Router and/or Network Server Controller(s): The BAS Contractor shall furnish (qty) Ethernet-based Network Server Controllers as described in Part 2 of the specification. These controllers will connect directly to the Operator Workstation over Ethernet at a minimum of 100mbps, and provide communication to the Standalone Digital Control Units and/or other Input/Output Modules. Network Server Controllers shall conform to BACnet device profile B-BC. In addition the BACnet router must support BBMD (BACnet Broadcast Management device) Network controllers that utilize RS232 serial communications or ARCNET to communicate with the workstations will not be accepted.

Network Controllers shall be tested and certified by the BACnet Testing Laboratory (BTL) as Network Server Controllers (B-BC). They must have data backup battery in case of power failure for real time clock (10 years) lithium (field replaceable) and for SDRAM (one month) Alkaline (field replaceable).

Standalone Digital Control Units (DDCs): Provide the necessary quantity and types of DDCs to meet the requirements of the project for mechanical equipment control including air handlers, central plant control, and terminal unit control. Each DDC will operate completely standalone, containing all of the I/O and programs to control its associated equipment. Each BACnet protocol DDC shall conform to the BACnet device profile B-AAC.

BACnet DDCs shall be tested and certified by the BACnet Testing Laboratory (BTL) as Advanced Application Controllers (B-AAC).

The Local Area Network (LAN) shall be either a 10 or 100 Mpbs Ethernet network supporting BACnet, Modbus, Java, XML, KNX, HTTP, and CORBA IIOP for maximum flexibility for integration of building data with enterprise information systems and providing support for multiple Network Server Controllers (NSCs), user workstations and a local host computer system.

The Enterprise Ethernet (IEEE 802.3) LAN shall utilize Carrier Sense Multiple/Access/Collision Detect (CSMA/CD), Address Resolution Protocol (ARP) and User Datagram Protocol (UDP) operating at 10 or 100 Mbps.

The system shall enable an open architecture that utilizes EIA standard 709.1, the LonTalk™ protocol and/or ANSI / ASHRAE™ Standard 135-2007, BACnet functionality to assure interoperability between all system components. Native support for the LonTalk™ protocol and the ANSI / ASHRAE™ Standard 135-2007, BACnet protocol are required to assure that the project is fully supported by the HVAC open protocols to reduce future building maintenance, upgrade, and expansion costs.

The system shall enable an architecture that utilizes BACnet with 76.8 K Baud protocol, as the common communication protocol between all controllers and integral ANSI / ASHRAE™ Standard 135-2008, BACnet functionality to assure interoperability between all system components. The AAC shall be capable of communicating as a MS/TP device or as a BACnet IP device communicating at 10/100 Mbps on a TCP/IP trunk. The AAC shall have a MS/TP bus that is capable of supporting up to 127 UEC's or VAVDDC's without the addition of repeaters. The ANSI / ASHRAE™ Standard 135-2008, BACnet protocol is required to assure that the project is fully supported by the leading HVAC open protocol to reduce future building maintenance, upgrade, and expansion costs.

LonTalk™ packets may be encapsulated into TCP/IP messages to take advantage of existing infrastructure or to increase network bandwidth where necessary or desired.

Any such encapsulation of the LonTalk™ protocol into IP datagrams shall conform to existing LonMark™ guide functionality lines for such encapsulation and shall be based on industry standard protocols.

The products used in constructing the BMS shall be BTL and/or LonMark™ or KNX compliant.

The software tools required for network management of the LonTalk™ protocol and the ANSI / ASHRAE™ Standard 135-2008, BACnet protocol must be provided with the system. Drawings are diagrammatic only. Equipment and labor not specifically referred to herein or on the plans and are required to meet the functional intent, shall be provided without additional cost to the Owner. Minimum BACnet compliance is Level 4; with the ability to support data read and write functionality. Physical connection of BACnet devices shall be via Ethernet IP or BACnet over Lon or MS/TP. Physical connection of LonWorks devices shall be via Ethernet IP or FTT-10A.

The system shall support Modbus, KNX, M-bus, Profi-bus and gateways shall be used.

Complete temperature control system to be DDC with electronic sensors and electronic/electric actuation of Mechanical Equipment Room (MER) valves and

dampers and electronic actuation of terminal equipment valves and actuators as specified herein. The BMS is intended to seamlessly connect devices throughout the building regardless of subsystem type, i.e. variable frequency drives, low voltage lighting systems, electrical circuit breakers, power metering and card access should easily coexist on the same network channel.

The supplied system must incorporate the ability to access all data using Java enabled browsers without requiring proprietary operator interface and configuration programs.

Data shall reside on a supplier-installed server for all database access.

A hierarchical topology is required to assure reasonable system response times and to manage the flow and sharing of data without unduly burdening the customer's internal Intranet network.

All work described in this section shall be installed, wired, circuit tested and calibrated by factory certified technicians qualified for this work and in the regular employment of the approved manufacturer's local field office. The approved manufacturer's local field office shall have a minimum of 3 years of installation experience with the manufacturer and shall provide documentation in the bid and submittal package verifying longevity of the installing company's relationship with the manufacturer when requested. Supervision, hardware and software engineering, calibration and checkout of the system shall be by the employees of the approved manufacturer's local field office and shall not be subcontracted. The control contractor shall have an in place support facility within 100 miles of the site with factory certified technicians and engineers, spare parts inventory and all necessary test and diagnostic equipment for the installed system, and the control contractor shall have 24 hours/day, 7 days/week emergency service available.

Provide a POT to view all system controllers and their data points from one location. The POT should be able to manage schedules, override set points and have multi-level user access.

Integration functionality

Mechanical Services
Provide full functionality
Refer to Schedule of Points for detailed requirements

Energy Management
Provide fully functional integration for monitoring purposes
Refer to the Schedule of Points for detailed requirements

Electrical systems: generators, automatic transfer switch, LT Panels, Main/ Sub main Switchboards, Distribution Boards & Motor Control Centers (MCC)
Provide full functionality
Refer to the Schedule of Points for detailed requirements

Uninterrupted power supplies (UPS)
Provide full technical diagnostic capabilities
Provide automatic real-time notification to vendor of UPS failure
Provide notification of impending UPS shutdown on BMS
Provide coordinated, automatic IP (e.g. through SNMP protocol) and BMS equipment shutdown on expiry of UPS battery autonomy time
Refer to the Schedule of Points for detailed requirements

The Security Management System
Provide status of the security system and accessibility to the security via TCP/IP interface.
Miscellaneous telecommunications systems
Provide monitoring and alarm only of major LAN equipment
Provide coordinated, automatic LAN (e.g. through SNMP protocol) and BMS equipment shutdown on expiry of UPS battery autonomy time
Refer to the Schedule of Points for equipment list.

LOAD MANAGEMENT SYSTEM

Description:

The Load Management System shall monitor and control the various parameters of the PV power systems at various sites and shall be integrated to send the data to the Control Room at MEW Headquarter building control room.

The Load Management System shall be a flexible system which is configurable to user specifics. It must support large range of features which enable the integration, monitoring and control of all photovoltaic system.

The integration of all systems shall be achieved through software programs, electronic components, hardware packaging and communication network through LAN IP and WLAN IP for remote access.

19.2 Scope of work:

Design, supply, install, label, test, commission, maintain and documentLoad Management System to cover whole project. Preliminary design of all system components situated within the container shall be submitted with the offer.

19.3 Quality Assurance:

C. **Applicable Standards**:

1) IEC 870-5-101
2) IEC 870-5-104
3) Other equivalent International Standards.

D. **Acceptable Manufacturers:**

All ISO 9001 and ISO 14001 certified Manufacturers, whose products have been in use for at least 10 years in Kuwait and shall be in the list of approved manufacturers of MEW. A valid certificate must be included in the tender document.

19.4 Submittals:

- Product data – Submit manufacturer's specifications, performance data, installation and maintenance instructions.
- Fill up the relevant Technical Schedule.

19.5 Product – Load Management System:

19.5.1 Description:

The Load Management System shall monitor the following parameters of all services in the project at different locations and send the data to the control room of solar system at MEW Headquarter located at South Surra.

The following parameters must be monitored as minimum:

t) Array Voltage DC

u) Grid voltage AC
v) Array current DC
w) Grid (injected) current AC
x) Array Power DC
y) Grid (injected) Power AC
z) Module temperature (cell temperature)
aa) Metrological readings (ambient temperature, ambient humidity, wind speed, irradiation)
bb) Daily/monthly solar insolation
cc) Accumulated daily / monthly/ yearly power generation from PV system.
dd) Smart consumption metering of electricity (solar and grid)
ee) Peak power generation (daily, monthly and annually).
ff) Peak values for data points with alert messages.
gg) Fault diagnosis and alarms routing.
hh) Door open alarm for inverter enclosure.
ii) Automatic cleaning and washing system for PV Panel.
jj) Integrated systems (IP CCTV and access control system for monitoring and security).

19.5.2 System components:

The system shall consist of the following:

F. Automation controller: Local monitoring and control unit inside the inverter with controller and LCD touch panel with minimum 12" mounted on the inverter for system accessibility and control. The touch panel to be anti-glare, scratch resistance, viewing summary screens for user customized parameters with minimum four data points at the same time per screen.

G. Communication network module: Local control station at each site to collect the data from all inverters and send them to Control room at MEW HQ, through gateway (internet / GSM / telephone line etc.).

H. Local control room at each location shall consist of the following equipment:

iii. Server to control and monitor PV Power system. The server should meet or exceed the following specifications:

- Mothers board: Intel, FSB≥1GHz,CPUs≥2, ≥8 coreCPU speed ≥ 3.0Ghz
- CPU word length: 64 bits
- Cache memory: ≥ 8MB per core

- RAM capacity: ≥ 8GB DDR3 SDRAM, speed ≥1333 MHz, ≥16 expansion slots
- Disk storage: ≥ 2TB 15K rpm SAS 6Gpbs, hot plug, ≥ 8 bays, RAID 0-6
- Network interface: Dual 10Gb embedded Gigabit Ethernet card
- Monitor: 21" LED HD wide monitor
- Graphic card: ≥ 1GB
- Sound card: Integrated sound card
- Optical drive: Internal SATA interface, ≥ 24xDVD±RW
- USB ports: ≥ 3 ports 2.0
- Expansion slots: ≥ 4 PCIe G2 slots
- Power supply: Dual, hot plug redundant power supply (1+1) ≥ 750W
- Accessories: Optical mouse, Arabic Qwerty keyboard, 19" LED DH monitor
- Rack rails: Sliding rails with cable management arm
- Operating system Windows based (latest version) with full installation and server configuration

iv. Laser color printer with the following specifications:

Color Laser Printer A4 Size (Network): New, original & Branded only with 3 years onsite comprehensive warranty. The printer's technical specification shall meet or exceed the following as minimum:

- Print technology: Laser
- Print speed (Black): Up to 20 ppm
- Print speed (Color): Up to 20 ppm
- First page out (Black): ≥ As fast as 9.5 seconds

- First page out (Color): ≥ As fast as 9.5 seconds
- Print resolution (Black): 600 x 600 dpi
- Print resolution (Color): 600 x 600 dpi
- Network: USB 2.0, gigabit Ethernet 10/100/1000 Mbps

v. **UPS:** 5kVA as minimum to operate the whole system equipment in the container for 6 hours, in case of power outage.

I. Passive network: LAN network of CAT6A F/UTP copper cable (100 Ohms, LSZH jacket), floor boxes, outlets, RJ45 faceplates, UTP Cat6A patch cords, free standing server cabinet with all required accessories (power supplies, cable management, fans, power distribution etc.), 2 core multimode (OM3) fiber optic cables for IP cameras connection.

J. Active Network: 16 port 10/100/1000 10GBase stackable managed switch.

19.5.3 System features:

The Software features actual screen shots have to be provided showing the required features and any extra features available. Features supported must include the following as minimum:

G. **Access:**

- Access to data shall be global with capability of user profile and role management and access right management, such that users can access data, history, point detail displays, etc. for data points with customized user privileges.

- The system shall have the ability to be accessed from any browser (Web enabled)via computers and smart phones by authorized person with security password.

- The load management system shall be accessed locally from the site server where **all** data points activated on the server to be linked to MEW HW control for the purpose of integration. The license should also allow multi workstations access with full software features and capabilities.

H. **Security/Filtering:**

It shall be possible to nominate sets of points to be accessed on a server-by-server and user-by-user basis. The mechanism shall be the same as the mechanism to control individual operator and workstation access to data for single server system.

The system has to be backed up with scheduled periods to insure data loss prevention and prevent data corruption with multiple periodic backups. Backups to be restored to any specific date in case of database corruption.

I. **Alarms /Messages:**

- Operators and workstations must be able to see events and alarms from any workstations or Web access to any application parameter with alarm viewer (security, maintenance, remote diagnostics, etc.).
- All alarms shall appear in the alarm list with specified priority and stored in central database. Each Alarm message should include shortcut to the relevant graphical system view with recommended actions.
- Having the system running with the ability to route alarms to user defined emails and SMS. User customized list of alarms and messages to be routed to pre-defined emails and phones.

J. **Trending:**

It shall be possible to configure real time and historical trends. It shall not be necessary to configure more than one point for each data value or signal, regardless of the number of users accessing the data.

The graphical trend must have the ability to customize user parameters of graph plotting (time scale, parameter scale, periods start and end configuration, etc).

K. **Graphics / Reports / Applications**:

The system has to provide user customized graphics and reports in record forms and accessed from anywhere (locally and web access). The reporting and plotting features has to be for both present live data and historical data for all measured parameters.

Customized graphs and trends capabilities is a must where reporting criteria can be modified as per user needs (selected data points, periods, values filtering, value setting, etc).

Customized reports with user ability to filter data, search with multi-level criteria and with customized periods (hourly, daily, monthly, annually).

All generated reports and graphs to be exported to standard printing formats (Excel, Word, PowerPoint, PDF)

L. **Interface:**

All systems features must be within the same graphical user interface for monitoring and control. The software can be installed on unlimited number of remote workstations through LAN IP providing all system features.

Integration and Web enabled technology:

- The information in Load Management System server must be available at internet through web access which supports simultaneous access of unlimited users with no required software installation via Web Access.
- The Load Management System should be web based technology and use IT Security strategies (firewalls, VPN) to interface with the existing Load Management Systemlocated at the main office of MEW for monitoring and collecting all measured data and trend points of the solar system to be present at MEW HQ control room solar server.
- The Load Management System controller **must**a use standard communication protocols to insure full integration and live data accessibility between project load management system and existing system at MEW HQ control room.
- The Load Management System controller should provide extension module and gateway web access permissions for Third Party controller at MEW Head Quarter which operates with BACnet/IP communications for full communication and integration.

- Full database integration between system database and MEW HQ Oracle/SQL database for live data uploading to MEW power server. The project database has to be linked to MEW power server database with customized data points.

19.7 Installation

- The installation shall be carried out according to manufacturer's Installation and Safety Instructions, supervised by manufacturer's Specialist. The system shall be installed by specialist sub-contractor approved by MEW for SCADA works.

The bid must include a diagram illustrating wiring to Photovoltaic system identifying each component, manufacturer and model number

- The license of Load Management System application has to be permanent and shows exact number of points to be measured (virtual and actual) and how many free points available for future growth.
- Real life simulation data has to be provided to test system prior to operating system. In case of inability to provide real life simulation data, a demo version of the software has to be provided prior to accepting it for the purpose of assessing the software features and capabilities.

19.8 Automatic washing system controller:

10) Supplied by manufacturer of the washing system complete with all valves and nozzles.
11) Controller must have manual and automatic control.
12) Controller with PLC and screen for system status.
13) Historical data to be stored in a non-volatile memory and reports to be retrieved with user defined settings.
14) The software has the capabilities for historical logs and data records retrieving.

15) Integrating the automatic washing system with the load management system at the project for monitor data points and control all data points.
16) System commissioning and testing to be with the presence of the manufacturer engineer.
17) All system components must of UL approved list.
18) The system to be with supplied with smart meter for water consumption

19.9 Approved manufacturers of Load Management System shall be of the following:

SIEMENS – GERMANY

ABB – ITALY

HONEYWELL – USA

SCHNEIDER – FRANCE

JOHNSON CONTROL – USA

TOSHIBA – JAPAN

SCADA

43.1. SYSTEM OVERVIEW

The Electrical network system designed for the MEW Mutla project shall consider Power Availability, Operability and Maintainability as the highest priority.

The overall design the Electrical System including SCADA must:

- Select equipment of the highest standards incorporating the latest communication technologies for each process and load (In all LV Switchboards, ACBs, MCCBs, MCBs, VFDs, Soft Starters, Meters, etc shall be capable of communicating directly on Ethernet TCP/IP protocol).
- Incorporate a plant electrical network architecture that is scalable, compatible with third-party equipment and employ standard / latest protocols.

- Implement a tested, validated and documented architecture to ensure system safety and also to ensure the system is implemented within a short period of time mitigating all risks.
- Implement a plant electrical network that immediately integrates with energy and waste monitoring systems.
- Implement an appropriate maintenance policy with corrective, preventive and predictive measures.
- Install a SCADA system with the following general features, to help operation and maintenance engineers make the right decisions and take appropriate corrective actions:
  - Real-time monitoring of the entire electrical network.
  - Control of assigned devices to achieve efficient plant operation with optimized response time.
  - Alarming, data logging, event tracking, fault analysis and root cause analysis.
  - Remote trouble shooting of power equipment and loads such as motors.
  -

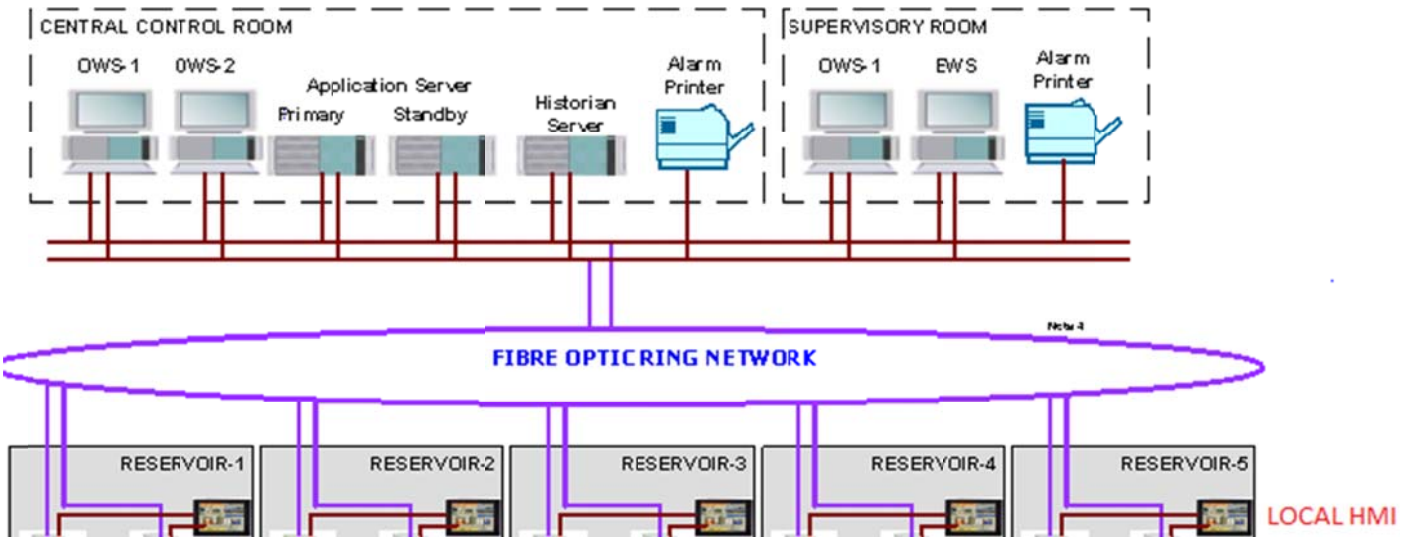
43.2. FULLY INTEGRATED CONTROL SYSTEM

Offered SCADA system with control and monitoring capabilities shall be installed in the MEW control room and with only monitoring capabilities shall be installed in the supervisory room and local monitoring at each reservoir MCC room.

MEW prefers to have a FULLY INTEGRATED CONTROL SYSTEM., I.e., The Main LT Panels, MSB, SMSB, MCC, PLC System, SCADA System shall be from ONE SINGLE MANUFACTURER.

43.3. SCADA SYSTEM ARCHITECTURE

The SCADA system proposed shall be based on the SYSTEM ARCHITECTURE shown below:



Note 1: The LV devices (ACB, MCCB, etc) will be located in main LT Panels/ MCC'S inside the substations

Note 2: Offered PLC shall be redundant at CPU, PSU and communication module level.

Note 3: Each Reservoir control system shall be equipped with 15" HMI as part of the SCADA system

Note 4: Optical Fiber link is proposed for communication between site systems (RTUs or PLCs) and MEW control Room and could be changed based on the distance and other factors. The sameis applicable for the connection link between supervisory room and the MEW control room

43.4. MAIN SCADA IN MEW CONTROL ROOM

The Main SCADA System in MEW control room shall include all the software and hardware required for the correct operation of the Control Centre.

The functionality of the Main SCADA System shall be to provide total remote operation and control of the daily activities related to the MEW Water Network.

Two Real-time SCADA servers shall be provided. The configuration shall be 'hot-standby'.

The Real-time SCADA servers shall perform all of the Real-time functions, including RTU polling, supervisory control, alarm detection, alarm processing and user-defined calculations.

One Historical SCADA server shall be provided. The configuration shall be hot-standby, sharing the disks array with historical information.

The Historical Services shall provide long-term storage of Real Time measurement, event, alarming and other pertinent data monitored or generated by the system. Historical Services shall offer flexibility for historical data store through a RDBMS.

Report Printers and Alarm Printers shall be provided.

The SCADA system will include multiple operator work stations for the monitor and control of the MCC equipment.

43.5. Supervisory Room

The SCADA system will include multiple operator work stations for the monitor of the MCC equipment.

Alarm Printers shall be provided.

Engineering Work Station along with all software required for programming the PLCs as well as the SCADA system shall be provided

43.6. SCADA – KEY REQUIRMENTS

As a minimum, the offered SCADA system shall have the following key requirements:

43.6.1. SCALABILITY

- Unlimited number of server systems.
- Unlimited number of display clients.
- SCADA Mobile provides real-time remote access to critical SCADA data, allowing system users to monitor performance while “on the move

43.6.2. REDUNDANCY

- Symmetric main-standby & capacity for triple standby server functionality.
- All redundancy shall be handled by the database, with the operational state of systems preserved through a server changeover. The system shall not

rely on driver redundancy for data transfer when providing redundant server. The system shall present a uniform view of data including communication status after a fail over.

- Fully automated data transfer between servers to provide complete server redundancy. This transfer shall include configuration, real-time data, historic data and event lists. Database updates shall be on an incremental basis.

43.6.3. FELIXIBILITY

- Where multiple servers are deployed, the system shall be capable of being configurable from a single client.
- Capable of operating Client/Server and Server/Server links over low to medium speed channels depending upon database size (e.g. 128K)

43.6.4. SECURITY

- Support Multi-level User Security Hacking
- Support DNP secure Authentication.
- Support for DMZ (read-only) servers

43.6.5. CONNECTIVITY AND COMMUNICATION

1. Shall have inbuilt unlimited communication capabilities with external devices and to support as a minimum industry-standard protocols

    1. DNP3.0 (Master & Slave)
    2. IEC870-5-101&104 (Master & Slave)
    3. Modbus
    4. OPC Client
    5. SNMP
    6. NTP

43.6.6. RELIABILITY

- Built-in system redundancy and data-backfilling features assure the highest degree of data reliability
- Support Triple Server Redundancy.
- Dual LAN and WAN redundancy.

43.6.7. GENERAL

Offered SCADA shall provide the following:

- Client / Server architecture based on TCP/IP networking and report-by-exception (RBE) technology
- Standalone single server operation.
- Permanent Standby Server designed to be placed outside corporate firewalls providing a read-only access to the server while ensuring corporate security.
- Additional servers for client load sharing and remote locations.
- Forced changeover between main and standby allowing seamless changeover between main and standby servers without shutting down either server.
- IEC78070 protocol shall be fully supported natively, including operation as a Master and DNP3 Slave
- Clients to connect to a synchronizing server as soon as the configuration and current data in the database has synchronized. Incomplete data sets as per clients request on event or trend provide indications that the synchronization is still in progress to ensure that conclusions are not drawn from incomplete data sets.

- SCADA Master Station Communication Front End Processor (CFP) and LAN shall be fully redundant such that no single failure causes any loss or derogation of SCADA functionality or performance. The SCADA Master System at the MEW shall be equipped with dual Communications.

- Offered SCADA system shall utilize non-proprietary industry standards to enable transparent connectivity to other hardware, software and network. The use of non-proprietary standards will not compromise the ability to satisfactory support and maintain the system during operation.

- Configurable compression of data communications between client/server and server/server to allow optimization of communications performance over WAN networks.
- Change reporting on Client/Server and Server/Server links rather than polled communication to permit operation on WAN networks.

- Capable of operating Client/Server and Server/Server links over low to medium speed channels depending upon database size (e.g. 128K)

- Application shall be native 32-bit and 64-bit versions and supported on Windows® Server and Workstation operating systems including Windows

2000, Windows XP, Windows 2000 Server, Windows 2003 Server, Windows 7 (32 and 64 bit) and Windows Server 2008 R2 and later.

- Built in telemetry functions such as:
    - IEC 60870-5-101/104 and DNP3
    - Local data storage
    - Automatic back-filling
    - Multiple WAN Communication handling
- Integrated SCADA function
    - Web-Server
    - Historian
    - Reporting generation
    - Alarm redirection

43.7. GLOBAL POSITIONING SYSTEM "GPS"

To ensure network time synchronization, between all systems Dedicated GPS synchronized system to be located at MEW building. All WSS equipment (including RTU systems) shall be synchronized to maintain a target accuracy of 50 milliseconds (or better) with reference to the GPS clock source.

43.8. PROGRAMMABLE LOGIC CONTROLLER

Intelligent programmable logic control at each Substation shall be installed near the equipment. The PLC system shall have the following key requirements

43.8.1. CONNECTIVITY AND COMMUNICATION

1. PLC shall be built in with different communication protocols like
    1. Modus TCP/IP
    2. Ethernet I/P
    3. Modbus Plus
    4. Modbus Serial (RS232,RS485)
    5. DNP3.0 master/slave
    6. IEC60870-5 master/slave

7. AS-Interface

2. In addition to the following transparent ready communication, service shall be integrated like:
    1. NTP Time synchronization
    2. SNMP network management service
    3. RSTP redundancy service to support Ring Topologies
    4. QoS (Quality of Service) service
    5. Automatic module configuration recovery using FDR service

43.8.2. GENERAL SPECIFICATION

1. The controller shall be natively Ethernet inside and similarly for the backplane.
2. PLC shall be of high availability with redundant CPU, redundant PSU, and redundant Communication modules and simplex I/O modules
3. One Dedicated 15” IPC Local Operator Work Station shall be provided for local monitoring.
4. Must have embedded fiber optic convertor for long distance cabling installation for single and multimode
5. PLC shall be microprocessor based and shall be modular in construction
6. Ethernet must be directly managed inside microprocessor of controller (rather than by a separate co-processor)
7. Natively embed web pages that can be reviewed on any device that IP Configured like IPAD, and android devices compliance
8. PLC programming shall be IEC 61131-3 compliant
9. Removable memory cartridge must provide up to 4 Go of memory capacity
10. No battery supply is needed for non-volatile backup.
11. Offered PLC for Substations shall be designed to operate in -25 to 70 Deg C temperature
12. Communication from the controller to the distribute I/O module will be via Ethernet Modbus TCP/IP or EtherNet/IP. Communication via any other protocol will not be accepted.

13. The configuration of the most powerful processor in the range will provide 4096 discrete I/O and 1024 analog I/O (cumulative values) and 64 counting channels
14. NTP server must be provided within the CPU.

43.8.3. PERFORMANCE

1. 1Gbps Ethernet interface in CPU
2. Communication network shall be deterministic for ERIO
3. CPU supports at least 32 requests of 1024 bytes per PLC Scan (up to 40 requests by adjusting a system word)
4. Event are time stamped at source level with a 1 ms accuracy
5. Execution time of instruction shall be in nanoseconds.
6. Shall have the ability to modify the following without stopping the PLC in order to reduce the process downtime :

    - Modify channel configuration parameters
    - Add/delete Digital (if not time stamped) & Analog I/Os modules
    - Hot swap capability for all I/O modules.
    - Add a drop in architecture
    - Online application modification during the process

43.8.4. FLEXIBILITY

1. Allowing changing architecture or configurations without stopping the process
2. Transparent access to data through Ethernet backbone
3. Get information online via integrated web server access

43.8.5. REALIBILITY

1. The SCADA and RTU equipment provided by the SUPPLIER shall have a minimum overall availability of 99.97%.

43.8.6. CYBER SECURITY

The offered PLC shall be robust and have the ability to face any Cyber attack

1. It shall be Achilles level 2 Certified.
2. Embedded security features in compliance with IEC62443 standards
3. Secure password encryption (in product & on the wire)

4. Firmware signature and integrity checks
5. Any data which could be helpful to reverse engineering the firmware has been removed
6. TCP/IP ports locked down by default

43.9. SWITCHGEAR SIGNALS TO SCADA

The following minimum Monitoring and Conrol signals shall be provided from 415V Switchgear to SCADA.

	MONITORING	CONTROL
ACB	• Breaker Status • All breaker settings • Ammeter measurement • Energy Measurement • Fault Indication / Cause of Trip • Maximeter / Minimeter readings	• Open / Close (only for Generator switchboard, MLTB and MCC)
MCCB	• Breaker Status • All breaker settings • Ammeter measurement • Energy Measurement • Fault Indication / Cause of Trip • Maximeter / Minimeter readings	• Open / Close (only for Generator switchboard, MLTB and MCC)
MOTOR STARTER	• Starter Status • All Starter settings • Energy Measurement • Fault Indication / Cause of Trip • Maximeter / Minimeter readings	• Open / Close (only for MCC)

Elevators

Provide alarm status notification of equipment and devices as defined in the Schedule of Points

Automatic system testing and reporting is excluded from BMS integration as it will be carried out by the Elevators and escalators management system

Fire Management System

Fire Detection and Alarm system will operate independently, but it will be integrated to BMS through BACnet /IP to provide additional alarm status notification of equipment and devices related to Fire mode operation of the building. The Fire alarm supplier to provide gateway as necessary. Coordinate with Fire Alarm System supplier for the integration

Integrate the Fire Alarm system into the BMS.

Alarm screen with appropriate graphics and location of activated devices superimposed on relevant part of the building layout shall automatically appear on designated workstations and audible signal shall alert the operator.

Any Fire Alarm system malfunction shall be annunciated in similar approved manner

Refer to Sequence of Operation for HVAC Controls, for relationship with smoke control system.

Refer to Fire Strategy for integration with Access Control and Security Management System.

SYSTEM ARCHITECTURE

General

The Building Automation System (BAS) shall consist of Network Server/Controllers (NSCs),Routers , a family of Standalone Digital Control Units (DDCs), Administration and Programming Workstations (APWs), and Web-based Operator Workstations (WOWs). The BAS shall provide control, alarm detection, scheduling, reporting and information management for the entire facility, and Wide Area Network (WAN) if applicable.

The system shall be designed with a top-level 10/100 Ethernet network, using the BACnet/IP, LonWorks IP, and/or Modbus TCP protocol. A sub-network of DDCs using the BACnet/Lon, LonTalk FTT-10A, and/or Modbus RTU, KNX protocol shall connect the local, stand-alone controllers with Ethernet-level Network Server Controllers/IP Routers.

The BMS shall use IEEE 802.3 Standard Local Area Network (LAN) for communications

Seamless integration is required with guaranteed interoperability for:
Data sharing
Alarm and event management
Scheduling
Trending
Device and network management

The BMS shall use a Client Server architecture based on a modular PC network, utilizing industry standard operating systems and protocols.

The architecture shall support distributed servers in a Distributed Server Architecture (DSA) to allow multiple and independent systems to communicate together for data exchange in order to provide an easy management and avoid duplicate engineering.

The architecture shall provide two levels of processing and control:

Central System Level: Workstations and Web clients.

Automation Level: local microprocessor based units that can interact between them and communicate with the Central System Level providing local processing and storage. This level shall be as independent as possible in order to provide full functionalities even in the event of a failure of the Central System or an outage of communication links.

BACnet DDC requirements: The system shall consist of freely programmable native BACnet , The system shall consist of one or more BACnet over Lon field buses. Minimum speed shall be 76.8kbps.

The communication bus to be BACnet over lontalk at 76.8 kbps or 10/100Mbits over Ethernet IP

LonWorks DDC requirements: The system shall consist of one or more LonWorks FTT-10A field buses managed by the Network Server Controller. Minimum speed shall be 76.8kbps. The field bus layer shall consist of up to 60 DDCs using peer-to-peer, event-driven communication for operation of HVAC and lighting equipment.

Multiple protocols: the BMS shall allow communications with a wide variety of proprietary and third party control devices utilizing off the shelf driver packages. It shall support BACnet, LON, Modbus, KNX and OPC standards for open system communications. All Network Server Controllers must natively support the BACnet IP, BACnet MS/TP, LonWorks IP, LonWorks FTT-10, Modbus TCP, Modbus RTU (RS-485 and RS-232), and Modbus ASCII protocols

BAS LAN Segmentation

The BAS shall be capable of being segmented, through software, into multiple local area networks (LANs) distributed over a wide area network (WAN). Workstations can manage a single LAN (or building), and/or the entire system with all portions of that LAN maintaining its own, current database.

High availability configurations shall be integrated in the system design in order to ensure operation in critical environments.

System Expansion

The BAS system shall be scalable, modular and expandable at automation level of the system using the same software interface, and the same TCP/IP level and fieldbus level controllers. Systems that require replacement of either the workstation software or field controllers in order to expand the system shall not be acceptable.

Web-based operation shall be supported directly by the DDC and/or GUI at the PC management level.

The system shall be capable of using graphical and/or line application programming language for the Network Server Controllers.

Integrated Maintenance Management

The BMS shall provide an integrated facility for maintenance management of plant and equipment. The maintenance facility shall tightly integrate with the BMS to retrieve data from field devices to determine when equipment or plant in the field requires maintenance

The maintenance facility shall automatically raise a works order request for a piece of equipment when certain maintenance conditions are met. Types of configurable maintenance events shall include duty cycles, run hours, and high data values. The works order shall be automatically printed or emailed to the configured responsible individual.
The user interface shall be based on Web technology, with all regular maintenance facility interaction occurring through a standard web browser. Systems that require additional software on client machines to allow viewing and configuration of the maintenance facility shall not be acceptable.
The maintenance facility shall use a standard reporting tool for generation of maintenance reports. Such reports shall include past and present works orders, equipment lists and equipment history reports. User customization of reports shall be possible via the standard reporting tool.
The maintenance facility shall store common asset information and provide easy addition of customer-defined information. User access shall be configurable, to enable user capabilities to be tailored or limited. It shall be possible to use equipment templates to allow definition of equipment with common data requirements without having to repeat data entry.

Scheduled Maintenance Parts Inventory Database
Aimed at future Facility Manager, this database shall include detailed inventory of all equipment parts that are to be periodically replaced e.g. air conditioning filters, water plant filters / consumables etc.
All parts shall be named / bar-coded according to a uniform, project wide system. Contractor to develop such system for Client's approval prior to any equipment order.
The Contractor is responsible for ensuring that equipment / parts are bar-coded accordingly and equipment delivered to site is entered into the database promptly and correctly.
Refer to Project Manager for further requirements.

CABLE SPECIFICATION

Fiber Optic Multi mode/Single Mode armored or protected in GI conduit/trunking as necessary is to be used as means of communications between buildings.

Structured Cabling System shall be used within the buildings as much as practicable

In addition, proprietary specification cables most suited to each application as recommended by manufacturer shall be used.

PROJECT SPECIFIC CONFIGURATION

Office building of main substation maintenance department at Subhan.

GENERAL PRINCIPLES
Integrated approach is used to management of all systems.
There will be Engineering room (BMS, manned 24 hours 365 days) that will manage the entire project.

The Engineering room shall accommodate BMS workstations, CCTV recording facilities, central battery system workstation, fire alarm annunciator panel, mimic panel , servers, printers UPS and peripherals.
The system shall perform checks on data integrity of all data acquired from each device. If an invalid or time out response is received, the data shall be ignored and the system will record the transaction as an error. Communications statistics shall be displayed as standard on the system and shall also be available as part of the reporting system or custom displays.
Once a control device is configured and placed in service, the system shall automatically begin background diagnostic scanning of the device to ensure that communications are monitored independently of any monitoring scanning.

VENDOR REQUIREMENTS

The vendor shall be a recognized leader in Facilities Integration, Building Automation Systems, Security Management, and Life Safety Management capable of supplying all necessary support services including hardware and software support, configuration services, system installation and commissioning and on-going support.

QUALITY ASSURANCE

The software supplied, as part of this system shall be developed in an ISO 9001 compliant environment.

EXTRA MATERIALS

Spare parts as recommended by the manufacturer, including but not limited to the following shall be furnished to the owner.
2 nos. Printer Ribbons, as appropriate
2nos. Toner Cartridges for Laser Printer, as appropriate
2 sets Cartridges for Color Printer, as appropriate

Spare Parts furnished under this clause shall not be used during the maintenance period without the written permission of the owner (Contractor shall procure spare parts, tools etc., fulfill his obligations to operate and maintain the system in the contract period).

PRODUCTS

MANUFACTURERS

Approved Manufacturers: Subject to compliance with the requirements of the Contract Documents, provide products by one of the following manufactures:
Honeywell
Johnson Controls

Siemens Building Technologies
TAC

HARDWARE
PC Workstation (One no. for BMS) plus (one more for the MMP)
The BMS workstations shall be located in control room at Annex building.
Intel® Core™ i7-2600 processor (4 Cores *I* 8 Threads, 3.40 GHz)
Memory: 4 GB DDR3
Supported capacity RAM (max.) :32GB
Storage: 500GB HOD SATA II, 7200 rpm
Optical Drive: DVD Super Multi
Multi Card Reader (20-in-1)
Audio codec Realtek ALC663
LAN: 10/100/1000 MBit/s Realtek RTL 8111 E
Graphics brand name: Intel® HD Graphics 2000
Shared video memory: up to 1759 MB
20" LED Monitor

Alarm Printers (One no.)
Alarm printers shall be high speed dot matrix printers to allow alarms to be printed in real time as they occur. These shall be high quality printers used for hardcopy alarm systems logs, information summaries, and control system malfunction advisories. The Printer shall be multi font, black and white output.
It shall have a minimum operating speed of 200 characters / second or higher
The system shall be capable of establishing the line count per page on site for form feed control
Printer shall be formatted to print on continuous paper.

Report Printers (One no.) plus (one more for the MMP)

High quality, high speed laser printers for hardcopy system printouts.

The printer shall be multi font, Color output.

It shall have a minimum operating speed of 200 characters / second or higher

Printer shall be formatted to print on standard A4 paper.

Distributed Direct Digital Controllers:

DDC Controllers

The level at which the actual processing takes place based on the logic written on the DDC. The processes are carried out at the DDC controllers for stand-alone control of all plant. The DDC Controllers should meet the following specifications.

Each DDC Controller shall have an Ethernet inbuilt providing the capability to integrate directly with the site IT infrastructure.

A system, which link the DDC Controllers to a Network Module, which in turn sits on Ethernet, is not acceptable.

Each DDC Controller shall have an IP router by itself supporting LAN & WAN Connectivity.

The DDC Controller shall support thin client connectivity.

The DDC Controller shall be equipped with a 32 Bit Microprocessor with a CPU Speed of minimum 66 MHz and an I/O Cycle Time of 1sec.

The DDC Controller shall have a provision to connect LCD Screen Display Unit for local access.

Each DDC Controller shall have a 16 MB SDRAM and 8 MB Flash Memory. Data within the DDC Controller shall be stored in a non-volatile memory. In the event of a mains failure, the Real Time Clock should be maintained for 10 years. The data base stored in SDRAM must be stored typically 1 month after power outages

The DDC Controller shall be modular and expandable by using Input/output Modules.LED indicators for Run, Fault, Battery condition, Communication as minimum to be present on the DDC.

The DDC controller shall have Minimum 12 numbers of Universal Inputs.

It should be possible to fix the Input/Output Modules at a distance of 30mtrs from the main DDC Controller.

The DDC Controller shall support additional points by the use of Expansion Modules and shall be connected through I/O bus.

The DDC controller shall have the capability to expand up to 128 I/O points.

The DDC Controller should meet the following Environmental Standards.

EMC Emissions: EN61000-6-3

EMC Immunity: EN61000-6-2

EU : EN61010-1:2001

Protection : IP20, NEMA1

UL Rated : 'UL916 listed open energy management equipment'

The Analog Inputs should have a 12 Bit resolution with a minimum 60dB series mode rejection at supply frequency.

The Analog Outputs should have a 11Bit resolution

The software capabilities of Controller shall include:

Analog Input / Output

Digital Input / output

Digital outputs shall be potential free outputs and Digital Pulses. Analog outputs shall be true analog outputs (0-10 V DC)

Capabilities to communicate with higher level

Holiday time schedules

Complex PID loops

Optimizer

Mean value calculation

Hysteresis

Logic Operations AND / OR / EXOR / NOT etc.

Optimum start/stop functions

Set point reset functions

Weekly/ Daily schedule

Utility functions for various functions like counter, drive, flow limit, logic, PWM, thermostat, status, Timer etc.,

APPLICATION SPECIFIC CONTROLLERS - HVAC APPLICATIONS

Each Digital Panel shall be able to extend its monitoring and control through the use of standalone Application Specific Controllers (ASCs).

Each ASC shall operate as standalone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall be a microprocessor-based, multi-tasking, real time digital control processor.

Each ASC shall have sufficient memory to support its own operating system and data bases including:

Control Processes

Energy Management Applications

Operator I/O (Portable Service Terminal)

The operator interface to any ASC point data or programs shall be through the Digital Panel or portable operator's terminal connected to any ASC on the network.

ASCs shall directly support the temporary use of a portable service terminal that can be connected to the ASC via zone temperature or directly at the controller. The capabilities of the portable service terminal shall include, but not be limited to, the following:

Display temperatures

Display status

Display set points

Display control parameters

Override binary output control

Override and log set points

Modification of gain and off set constants

Power fail Protection: All System set points, proportional bands, control algorithms, and

any other programmable parameters shall be stored such that a power failure of any duration does not necessitate reprogramming the ASC.

Application Descriptions:

VAV Terminal Unit Controllers:

VAV Terminal Unit Controllers shall be LONMARK / BACnet / KNX certified and shall support, but not be limited to, the control of VAV boxes both Bypass type and shut off type to address current requirements described in the "Automatic Control Sequence Section ":

VAV Terminal unit controllers shall include an inbuilt air flow

Transducer that shall connect to the terminal unit manufacturer's standard air velocity averaging grid to measure directly the average air flow in the duct.

VAV Terminal Unit Controllers shall support the following types of point inputs and outputs:

Proportional Cooling and Heating Outputs

VAV Terminal Unit Controllers shall support the following library of control strategies to address the requirements of the sequences described in the "Automatic Control Sequence Section " portion of this specification:

Daily Schedules

Comfort/Occupancy Mode

Economy Mode

Standby Mode

Unoccupied

Shutdown

Lighting Logic Interlock to Economy Mode

Temporary Override Mode

Temporary Comfort Mode (Occupancy-Based Control)

Boost

Occupancy-based Economy / Comfort Mode Control: Each VAV Terminal Unit Controller shall have a provision for occupancy sensing overrides. Based Upon the contact status of either a manual wall switch or an occupancy sensing device, the VAV Terminal Unit Controller shall automatically select either Economy or Comfort mode.

Temporary Override Modes

Temporary Occupancy Mode: The controller interface the zone temperature sensor shall allow for an optional momentary switch to change the mode of the controller from economy to comfort and optionally interlock the room lights for a present amount of time.

The controller interface to the zone temperature sensor shall allow for an optional

momentary switch to override the controller's output to full heating or cooling. This command shall be active for a preset amount of time, to anticipate a substantial change in the room's load.

Alarm Management: Each VAV Terminal Unit Controller shall perform its own limit and status monitoring and analysis to maximize network performance by reducing unnecessary communication

Unitary Controllers:

Unitary Controllers shall be LONMARK / BACNET certified and shall support, but not be limited to, the following types of systems to address specific applications described in the "Automatic Control Sequence Section" portion of this specification

Unitary controllers shall support the following library of control strategies to address the requirements of the sequences described in the "Automatic Control Sequence Section" portion of this specification

Temporary Override Modes

Temporary Occupancy Mode: The controller interface to the zone temperature sensor shall allow of an optional momentary switch to change the mode of the controller from economy to comfort and optionally interlock the room lights for a preset amount of time.

Boost Mode: The controller interface to the zone temperature sensor shall allow for an optional momentary switch to override the controller's output to full heating or cooling. This command shall be active for a preset amount of time, to anticipate a substantial change in the room's load.

Air Handling Unit (AHU) Controllers:

AHU Controllers shall be UL Listed and CE or equivalent certified stand alone and shall support, but not be limited to, the requirements as described in the "Automatic Control Sequence Section" portion of this specification.

AHU Controllers shall support all the necessary point inputs and outputs to perform the specified control sequences in a totally standalone fashion.

AHU Controllers shall have a library of control routines and program logic to perform the sequence of operation specified in the "Automatic Control Sequence Section" portion of this specification.

Continuous Zone Temperature Histories: Each AHU Controller shall automatically and continuously maintain a history of the associated zone temperature to allow users to quickly analyze space comfort and equipment performance for the past 24 hours. A minimum of two samples per hour shall be stored.

Alarm Management: Each AHU Controller shall perform its own limit and status monitoring and analysis to maximize network performance by reducing unnecessary communications.

Chillers / Pumps / Fans / Heat Exchangers / Boilers DDC Controllers

DDC controllers for the above equipment shall be UL listed and CE or Equivalent certified

and shall support but not limited to the requirements as described in the “Automatic control sequence section and the Schedule of points portion of the specification.

The DDC Controllers for the above shall comply with the specification requirements mentioned above in this document and shall support all necessary inputs points and output points to perform the specified control sequences in a totally standalone fashion.

These DDC Controllers shall have a library of control routines and program logic to perform the sequence of operation specified in the "Automatic Control Sequence Section” portion of this specification.

Continuous Zone Temperature Histories: Each DDC Controller shall automatically and continuously maintain a history of the associated zone temperature to allow users to quickly analyze space comfort and equipment performance for the past 24 hours. A minimum of two samples per hour shall be stored.

Alarm Management: Each DDC Controller shall perform its own limit and status monitoring and analysis to maximize network performance by reducing unnecessary communications.

Sensors, Switches, Control Dampers, Control Valves, Actuators
Refer Section 22.10.3.15 BAS controls & Instrumentation.

Point Schedules
See attached pages for schedule of points.

Sequence of Operation
Refer to "Sequence of Operations for HVAC Controls" section.

SYSTEM SOFTWARE
The BMS system server shall be based around the Microsoft Windows 32 bit multi-tasking environment, Win XP, Win 7. The system shall be a true 32-bit application to take advantage of Microsoft Windows enabling technologies.
Standard services supported by the server computer operating system will include the following:
Multi-tasking Multi-user support
TCP/IP Network Support
Graphic Display Building Editor
Application software
Software at the Operator Workstation shall comprise of:
Windows XP/ WIN 7 32 BIT Pro SP2
TCP/IP Networking
Graphic Display Building Editor
Application software
The networking software shall use the industry standard TCP/IP LAN protocol.
All system peripherals shall be capable of being connected to the server computer via the LAN.

OPERATOR INTERFACE

General

The operator interface provided by the system shall allow for efficient communication of operational data and abnormal conditions. Critical areas (such as alarm icons) shall be visible at all times. A predefined area on the screen shall provide operator messaging, and this area shall also be visible at all times. A set of standard displays for configuration, and navigation around the system are to be provided with every system and shall not require any additional engineering. The system shall also provide an unlimited number of custom (facility specific) displays created to meet the needs of the specific facility.

The tool bar and pull down menus shall be fully configurable. Similarly, such functions shall also be available via a standard set of Function-Key based pushbuttons without requiring configuration. The operator interface shall support the ability to “full screen lock” the window so users cannot access other applications.

Web Browser Operator Interface

The operator interface shall also be fully available through a web browser. From a standard browser such as Microsoft’s Internet Explorer, an operator shall be able to perform all functions on the same standard and custom displays as used in the standard operator interface. The browser interface shall provide login and security authentication in the same way as the standard operator interface.

Operator Interface Connection

The operator interface shall be flexible in its connection to the system server(s). An Ethernet LAN connection shall be used between the Server and the Operator Workstations. The operator interface shall provide standard dial-up modem support using Microsoft Remote Access Service (RAS).

The operator interface LAN connection shall also be flexible to support both permanent and casual access to the system server either through the standard operator interface or through a browser. Licensing shall be based on the “number of simultaneous operator connections” on a “First Come First Served” basis. Those users with casual access shall automatically disconnect from the FMS server after an idle timeout period.

Operator Interface Characteristics

The system shall provide a Windows operator interface with the following minimum capabilities as standard. No custom programming or scripting shall be necessary to produce these:

Window re-size, Zoom in, Zoom out

Dedicated icons and Pull Down Menus to perform the following:

Associated Alarm Display

Alarm Summary

Alarm Acknowledgement

Display Sequence Forward/Backward

Previous Display Recall (minimum of 8 displays)

Cardholder Detail

Pop up face plates

Alarm Banner showing highest priority, most recent (or oldest) unacknowledged alarm
System Date and Time Zone
Current security Level
Workstation connection number
Alarm Annunciation
Communications Fail Annunciation
Operator Message Zone

OPERATOR SECURITY AND SIGN-ON

User Interface:

The BMS workstation software shall allow the creation of a custom, browser-style interface linked to the user when logging into any workstation. Additionally, it shall be possible to create customized workspaces that can be assigned to user groups. This interface shall support the creation of "hot-spots" that the user may link to view/edit any object in the system or run any object editor or configuration tool contained in the software. Furthermore, this interface must be able to be configured to become a user's "PC Desktop" – with all the links that a user needs to run other applications. This, along with the Windows user security capabilities, will enable a system administrator to setup workstation accounts that not only limit the capabilities of the user within the BAS software, but may also limit what a user can do on the PC and/or LAN/WAN. This might be used to ensure, for example, that the user of an alarm monitoring workstation is unable to shut down the active alarm viewer and/or unable to load software onto the PC.

User Security

The software shall be designed so that each user of the software can have a unique username and password. This username/password combination shall be linked to a set of capabilities within the software, set by and editable only by, a system administrator. The sets of capabilities shall range from View only, Acknowledge alarms, Enable/disable and change values, Program, and Administer. The system shall allow the above capabilities to be applied independently to each and every class of object in the system. The system must allow a minimum of 256 users to be configured per workstation. Additionally, the software shall enable the ability to add/remove users based upon Microsoft Windows Security Domains that enable the customer IT department to assist in user access.

Configuration Interface

The workstation software shall use a familiar Windows Explorer□-style interface for an operator or programmer to view and/or edit any object (controller, point, alarm, report, schedule, etc.) in the entire system. In addition, this interface shall present a "network map" of all controllers and their associated points, programs, graphics, alarms, and reports in an easy to understand structure. All object names shall be alphanumeric and use Windows long filename conventions.

The configuration interface shall also include support for user defined object types. These object types shall be used as building blocks for the creation of the BAS database. They shall be created form the base object types within the system input, output, string variables, set- points, etc., alarm algorithms, alarm notification objects, reports, graphics displays, schedules, and programs. Groups of user defined object types shall be able to be set up as a predefined aggregate of subsystems and systems. The configuration interface shall support copying/pasting and exporting/importing portions of the database for additional efficiency. The system shall also maintain a link to all “child” objects created. If a user wishes to make a change to a parent object, the software shall ask the user if he/she wants to update all of the child objects with the change.

Color Graphic Displays

The system shall allow for the creation of user defined, color graphic displays for the viewing of mechanical and electrical systems, or building schematics. These graphics shall contain point information from the database including any attributes associated with the point (engineering units, etc.). In addition operators shall be able to command equipment or change set points from a graphic through the use of the mouse.

Security

The software shall be designed so that each user of the software can have a unique username and password. This username/password combination shall be linked to a set of capabilities within the software, set by and editable only by, a system administrator. The sets of capabilities shall range from View only, Acknowledge alarms, Enable/disable and change values, Program, and Administer. The system shall allow the above capabilities to be applied independently to each and every class of object in the system. The system must allow a minimum of 256 users to be configured per workstation. Additionally, the software shall enable the ability to add/remove users based upon Microsoft Windows Security Domains that enable the customer IT department to assist in user access.
If necessary, each operator may be assigned a user profile that defines the following:

Security and/or Control Level

Operator Identifier

Unique Password

Area Assignment / Area Profile

Start display for that operator

Timeout Value for that operator

Any actions initiated by the operator shall be logged in the Event database by operator identifier. In addition, any control actions shall only be allowed if the control level configured in the operator's profile exceeds the level assigned to the controlled point.

Utilities shall be provided to allow administration of the operator passwords.

Security Levels

The system shall support at least six levels of operator security. The functions allowed from each security level shall be as follows:

Level 1: Signed Off mode - View start-up display only.

Level 2: View only - The operator shall be able to view displays. Typically used for an inexperienced operator.

Level 3: Permit all Level 1 and 2 functions and in addition the operator shall be permitted to control points such as start/stop, disable/enable, etc. and acknowledge alarms as they occur.

Level 4: Permit all Level 1 through Level 3 functions in addition to accessing master time schedules, system peripherals allocation, change parameters, build reports and use most standard system configuration displays. This level shall typically be reserved for the system supervisor.

Level 5: Permit all Level 1 through Level 4 functions in addition to accessing the engineering functions such as building and linking displays, allocating keyboard push button assignments, etc. (Reserved for the system engineer).

Level 6: This is the highest level of station security and shall allow the user unlimited access to all station functions (Typically reserved for the system manager).

Sign-On/Sign-Off

The operator shall be permitted to sign on to the system if the correct Operator Identity and the Operator Password have been entered. This password shall be encrypted in the database. It shall also be possible to have the system linked to Windows such that the operator uses their Windows Account Name and password to sign on to the system. This ensures that operators only need to remember one set of credentials.
After a series of three unsuccessful attempts to sign-on the Operator Workstation interface shall be locked for a configurable period of time. The lockout period shall be set via system configuration displays. During Operator Workstation lockout the other Windows functions of the computer running the Operator Workstation software shall not be affected.

It shall be possible to assign operators either single or multi-user passwords. Single user passwords enable the operator to sign-on to only a single Operator Workstation thus preventing simultaneous sign-on be the same operator. Operators with the highest sign-on security level who may require simultaneous access to more than one Operator Workstation would typically use the multi-user password.

Each operator shall be assigned a password and a set of authorized areas and time periods. The operator may sign-off at any time by issuing a sign-off command.

A keyboard time-out feature shall be provided such that the operator shall be automatically signed off after a defined period of keyboard inactivity. It shall optionally be possible to configure automatic call-up of a "logged-out" display when this occurs to hide previously displayed restricted information.

Duress

It shall be possible for an operator to indicate that they are signing on under duress. The system shall recognize that the operator is signing on under duress and it shall then be able to issue a control to alert appropriate assistance.

Command Partitioning

It shall be possible to assign to each operator a set of allowed commands for each assigned area, where an area is a group of points. These commands can be mapped against the output state of any given digital point in the respective area to determine whether a control command is allowed for the particular operator.
With this feature, it shall for example be possible to configure an operator to set a digital point to ON, but to disallow the same operator from setting the same digital point to OFF.

STANDARD SYSTEM DISPLAYS

The following displays shall be included as part of the BMS system:

Alarm Summary Display

Event Summary Display

Point Detail Template Displays (for each point in the database)

Communications Status Displays

System Status Displays

Operator Scratch-pad Display

Face Plates for all common point types

Configuration Displays

The Alarm Summary, Event Summary, Point Detail, Communications Status, System Status shall not require any configuration.

Systems where standard graphical displays, showing all parameters for each system Point, do not exist shall not be acceptable.

CUSTOM DISPLAYS

The BMS shall include a Graphic Display Building editor for the creation of site specific graphic displays. It shall allow one-step online building of display static and dynamic objects. It shall allow the displays drawn using the editor to appear exactly the same when viewed from an Operator Workstation.

Displays shall be created in the HTML format. This is essential so that the displays can also be viewed through a web browser as well as the normal BMS operator interface. The displays must be saved in the standard HTML format. All graphic elements shall be available as HTML elements.

It shall be possible to link dynamic objects to the BMS database. They shall allow information to be displayed from the database or to allow an operator to interact with them in order to make changes in the database and to perform control actions.

It shall include static and dynamic display objects on the one display. The editor shall allow display objects to be manipulated by pointing, clicking and dragging. The editor shall allow display objects to be drawn, re-sized, copied, grouped, rotated, aligned and layered over each other. It shall be possible to copy and paste objects within and between displays.

Requirements of the color graphic subsystem include:

At a minimum, the user shall have the ability to import .gif, .png, .bmp, .jpeg, .tif, and CAD generated picture files as background displays, and layering shall be possible.

It shall be possible for the user to use JavaScript to customize the behavior of each graphic.

The editor shall use Scalable Vector Graphics (SVG) technology.

A built-in library of animated objects such as dampers, fans, pumps, buttons, knobs, gauges, ad graphs which can be “dropped” on a graphic through the use of a software configuration “wizard”. These objects shall enable operators to interact with the graphic displays in a manner that mimics their mechanical equivalents found on field installed control panels.

Using the mouse, operators shall be able to adjust set points, start or stop equipment, modify PID loop parameters, or change schedules.

Status changes or alarm conditions must be able to be highlighted by objects changing screen location, size, color, text, blinking or changing from one display to another.

Ability to link graphic displays through user defined objects, alarm testing, or the result of a mathematical expression. Operators must be able to change from one graphic to another by selecting an object with a mouse - no menus will be required.

It shall be possible to create and save graphical components and JavaScript code in reusable and transferrable, customized libraries.

Additionally, the Graphics Editor portion of the Engineering Software shall provide the following capabilities:

Create and save pages.

Group and UN group symbols.

Modify an existing symbol.

Modify an existing graphic page.

Rotate and mirror a symbol.

Place a symbol on a page.

Place analog dynamic data in decimal format on a page.

Place binary dynamic data using state descriptors on a page.

Create motion through the use of animated .gif files or JavaScript.

Place test mode indication on a page.

Place manual mode indication on a page.

Place links using a fixed symbol or flyover on a page.

Links to other graphics.

Links to web sites.

Links to notes.

Links to time schedules.

Links to any .exe file on the operator work station.

Links to .doc files.

Assign a background color.

Assign a foreground color.

Place alarm indicators on a page.

Change symbol/text/value color as a function of an analog variable.

Change a symbol/text/value color as a function of a binary state.

Change symbol/text/value as a function of a binary state.

All symbols used by Schneider Electric Buildings Business in the creation of graphic pages shall be saved to a library file for use by the owner.

Display Scripting

It shall be possible to further animate display elements using standard HTML scripts such as JavaScript or VBScript. A script editor supporting one of the standard script languages shall be provided. By using script programs, individual elements on the display may be manipulated. A proprietary scripting language or additional scripting and drawing package shall not be acceptable.

Web Technology

All displays including custom displays shall be usable in a standard Web Browser such as Microsoft's Internet Explorer without modification. All displays shall be usable in this manner enabling operators to completely operate the system through a web browser if required. Displays may also incorporate data from an intranet, the Internet, or ActiveX documents along with other building data.

ONLINE HELP AND DOCUMENTATION

The Operator interface shall also have access to online help and full system documentation. Online help shall be fully searchable and cross referenced to all relevant sections of the documentation. It shall be possible to browse the online help and set "favorites" which link to commonly used sections of the help information. All manuals shall be available online.

MONITORING AND CONTROL

Monitoring: the system shall support acquisition of data using the following techniques:
Periodic Scanning
Report by Exception
Data on demand

In order to minimize communications traffic, the system shall automatically block data requests using contiguous addresses and the scan intervals to generate scan packets, optimizing throughput for a given scanning load. The system shall also provide utilities to examine scan packet allocation for each scan interval, and compile aggregate statistics on communication link usage.

Device Control

A method shall be provided for control transactions issued by the operator to ensure the integrity of the transaction. The priority of the control failure alarm shall be configurable by the user.

SYSTEM DATABASE

The system shall provide a real-time database incorporating data from all inputs. The database shall be configurable by the end user without the need for any programming and shall be able to be modified on-line without interrupting operation of the system. In addition to point-based information, the database shall also provide historization capabilities for analog, digital, pulse and event based information. This information shall be accessible by all facilities of the system such as custom displays, reports, trends, user written applications, etc.

Database Structure

The real-time database shall support collection and storage of data.

Database backup shall be possible with the system on-line including backup of historical based data. The backup shall be possible via standard Microsoft Windows operating system utilities.

Grouping of Points

The BMS system shall provide a means by which a number of alarm inputs, outputs and other related points can be grouped together for more convenient monitoring and control

without the need for custom graphics.

History Management
Collection of historical point data shall be configurable as part of the point definition. Once configured, this data shall be collected automatically.
History shall be able to be archived to an alternative file system or offline media. Different archive settings shall be available for different history types.

Trending
The system shall provide flexible trending allowing real-time or archived data to be trended in a variety of formats. In addition, trend data types shall be able to be combined to allow for comparisons between data e.g. current real-time data versus archived data. All trend configurations must be possible on-line without interruption to the system.

User Definable Database
In order to support other types of data such as user entered or calculated data from application programs, the system shall also provide a User Definable database area that can be fully integrated into the system. Data contained in this database must be accessible by:
Custom Graphics
Custom Reports
Application Programs
Network Applications using a Network API

EVENT MANAGEMENT

It shall be possible to log an event such that it shall be journalized in the event file and optionally printed on the event printer. The journal shall contain the following event information:

Alarms

Alarm Acknowledgements

Return to Normal

Operator Control Actions

Operator Login & Security Level Changes

On-line database Modifications

Communications Alarms

System Restart Messages

Database changes

Standard Displays shall be provided to show the current journal file with the most recent event at the top of the display (LIFO). Subsequent page forward actions shall allow display of progressively older events. Sorting and filtering of the journal shall be possible

directly on screen. Filters shall be able to be saved for future use. Filtered events shall be able to be printed as an event report directly from the Event display.

Events may be sorted by time and date, database partition or source of the event. It shall be possible to apply filters to the list of events to limit the view of events to those that match the filter. Filters may include multiple dimensions and wildcards and shall also be able to be saved and restored for reuse.

It shall be possible to have an on-line event file as large as the disk capacity can accommodate. For example, given the appropriate disk space it shall be capable of storing more than 1,000,000 (one million) events on-line.
The event file shall store events online. The system shall be able to automatically or manually archive these online events periodically, at a time period specified by the user. Operators shall be notified by an alarm that event archiving is required if manual operation is chosen. Events may be archived to tape, or to other media such as CD, Zip drive or to other file systems. If archiving does not take place, the event system shall continue to collect events until it reaches a nominated disk space limit. It shall then overwrite the oldest events until archiving takes place or more disk space is made available.

Archived events may be restored to the system at a later time if required for reporting purposes. Multiple archives shall be able to be restored at any one time. The system shall indicate to the operator the range of events in a particular archive file.

ALARM MANAGEMENT

Alarm management shall be part of the BMS and based upon common facilities and procedures for all systems, SMS included.

Alarm Priorities

Each monitored point in the system shall be able to be assigned one of six alarm class or priorities (Urgent, High Priority, Normal alarm, Low Priority, User defined, Offline trend) to individual states. The lowest priority changes of status shall only be journalized and optionally printed on the Alarm/Event printer. Higher priority changes of status will appear in the Alarm Summary and optionally printed on the Alarm/Event printer.
Within each of the six alarm types there shall be sub-priorities available. Each alarm priority shall have a configurable color. It shall be possible to configure a time such that if an alarm is not acknowledged within this time the alarm's priority is elevated to the next level.

For each alarm priority, it shall be possible to configure a point such that if any alarms of this priority occur, the point is controlled to the configured state. This could be used to drive external enunciators such as sirens or lights. When an alarm is acknowledged, it

shall be possible to automatically issue a reset to a controller to indicate the alarm is acknowledged and to attempt to reset the alarm point.

Alarm Annunciation

Most recent, highest priority alarm message appearing on dedicated alarm banner on the operator interface. Alarm message appearing on alarm summary display.
Available Tone - based on a "*.wav" or other sound file for each alarm priority
Alarm message printed on the alarm printer
Alarm indicator flashing on the operator interface
Alarms shall be enunciated at the Operator Workstation even if there is no operator currently signed-on.

Alarm Processing

Assigning an alarm to the point shall automatically cause the system to perform the following actions when an alarm occurs:
The alarm shall be time stamped to the nearest second and logged in the Event database with the Point Name (source), Alarm type, Alarm Priority, Point Description, New value and Engineering Units
The point value which is in alarm shall turn red (or other configurable color) and flash on any standard or custom display which uses that point.

Alarm Summary

Alarms shall be able to be viewed in a consolidated alarm summary which shows all current or pending alarms on the system. This summary may be sorted by time and date, database partition or source of the alarm. The fields shown on the alarm summary must be configurable and it shall be easy to move or change the alarms fields displayed. It shall be possible to apply filters to the list of alarms to limit the view of alarms to those that match the filter. It shall be possible for the operators to add comments to the alarm and these comments shall be stored with the alarm.
Dedicated Alarm Banner and Alarm Indicator
A dedicated alarm banner shall appear on all displays showing either the most recent or oldest (configurable), highest priority, unacknowledged alarm in the system. This banner shall be clear when there are no unacknowledged alarms for the operator to process. An alarm indicator shall also appear on all displays.

Alarm Logging
As well as being logged on the printer, alarms shall be logged to an event file for future retrieval in alarm reports or archived to removable media.
Alarm Response Function Keys
The following dedicated function keys shall be provided on the keyboard for alarm action:

ACKNOWLEDGE
After moving the cursor to the point in alarm on the screen and selecting the point the operator shall be able to acknowledge an alarm by pressing this key. This action shall be logged in the event file and on the printer showing the operator ID with the alarm.

ALARM SUMMARY

By pressing a dedicated key at any time the operator shall be able to view a display showing all currently active alarms. The alarm messages shall be color-coded showing priorities. The operator shall be able to view the alarms according to priority or sorted based on other fields. It shall be possible to acknowledge alarms from this display and also go to the associated display defined for the point.

ASSOCIATED DISPLAY

After moving the cursor to the point in alarm on the screen and selecting the point the operator shall be able to bring up the display applicable to that alarm by pressing this key. Just selecting the associated display key directly will bring up the associated display for the point currently on the alarm banner. This is generally a custom graphic showing the location of the alarm in the facility.

Alarm Link to Digital Video Recordings

The system shall allow the linking and display of digital video recordings pertaining to alarms. If there is any video footage in digital format that is relevant to an alarm, then the alarm summary shall indicate this by the use of a special icon on the alarm. By selecting the icon, the operator can then replay the relevant digital video footage of the alarm incident.

Print Alarms as a Report

The filtered alarm summary should be able to be printed directly as a report. From the alarm summary page, it shall be possible to view the current filtered list of alarms via a print preview button. This shows what the alarms will look like when printed to the configured report printer. From the alarm summary, it shall be possible to print the alarms directly using the print button.

REPORTING

Reporting shall be part of the BMS and based upon common facilities and procedures for all systems.

The system shall support a flexible reporting package to allow easy generation of report data. The reports provided shall include pre-configured standard reports for common requirements such as Alarm Event reports and custom report generation facilities that are configurable by the user.

Standard Reports

Configuration of standard reports shall only require entry of the schedule information, and other parameters such as Point Name or wildcard, filter information, time interval for search and destination printer to fully configure the report. Specifically, no programming or scripting shall be required.

Additional Generic or Custom Reports

In addition, configurable report generation facilities must be provided to allow custom

reports to be produced. They shall be able to be configured at any time with the system online, and shall be able to access any database values.

Report Generation

47. The Reports Server shall be able to process large amounts of data and produce meaningful reports to facilitate analysis and optimization of each installation.

48. Reports shall be possible to generate and view from the operator Workstation, and/or Web workstation, and/or directly from a reports-only web interface.

49. A library of predefined automatically generated reports that prompt users for input prior to generation shall be available. The properties and configurations made to these reports shall be possible to save as Dashboard reports, so that the configurations are saved for future used.

50. It shall be possible to create reports standard tools, such as Microsoft Report Builder 2.0 or Visual Studio, shall be used for customized reports.

51. Additional reports or sets of reports shall be downloadable, transferrable, and importable

52. All reports shall be able to be set up to automatically run or be generated on demand.

53. Each report shall be capable of being automatically emailed to a recipient in Microsoft Word, Excel, and/or Adobe .pdf format.

54. Reports can be of any length and contain any point attributes from any controller on the network.

55. Image management functionality shall be possible to enable the system administrators to easily upload new logos or images to the system.

56. It shall be possible to run other executable programs whenever a report is initiated.

57. Report Generator activity can be tied to the alarm management system, so that any of the configured reports can be displayed in response to an alarm condition.

58. Minimum supplied reports shall include:

    a. Points in each controller

    b. Points in alarm

    c. Disabled points

d. Overridden points
e. Operator activity report
f. Alarm history log
g. Program listing by controller with status
h. Network status of each controller
i. Activities Per Server Report
j. Activities Per User Report
k. Alarm Amount by Category Report
l. Alarm Amount by Type Report
m. Alarms Per Sever Report
n. Current Alarm Report
o. Most Active Alarm Report
p. System Errors Per Server Report
q. Top Activities Report
r. Top Alarms Report
s. Top System Errors Report
t. Trend Log Comparison Report
u. User Logins Report
v. Users and Groups Reports

59. Minimum Energy Reports shall include:

a. Energy Monitoring Calendar Consumption Report: Shall provide an interactive report that shows the energy usage on one or multiple selected days.
b. Energy Monitoring Consumption Breakdown Report: Shall provide a report on energy consumption broken down using sub-metering.
c. Energy Monitoring Consumption Report: Shall show the energy consumption against a specified target value.

60. Reports Server Software Requirements

a. Microsoft Windows Server 2008 32-bit or Windows 7 32-bit
b. Microsoft SQL Server 2008 with Advanced Services
c. Microsoft Net 3.5 SP1.

HISTORICAL DATA ARCHIVING

The system shall support archiving of historical data to allow a continuous record of history to be built up over a period of time. Archived data shall be stored on the hard disk of the system. The number of archives maintained on the system before transfer to off-line media shall only be limited by the size of the hard disk. The system shall allow the user to define the specific intervals of history to be archived to avoid archiving of unnecessary data.

Once archived, the data shall be available for re-trending through the system trend facilities in combination with the current on-line history or other archives. Providing the archived history is present on the BMS Server's hard disk, the trend facilities must be able to access it transparently for display, when a user scrolls beyond current on-line history limits.

Time Schedules

It shall be possible to specify time schedules for the control of all BMS points. A single time schedule shall define the control to any combination of day and time. The BMS time schedule must also provide the ability to override the normal schedule for holidays or special occasions.

Configuring time schedules must be done through a graphical user interface whereby the operator selects the appropriate time span from a calendar.

Where the control device supports an internal time schedule program, the BMS shall be able to upload, display, modify and download the control device time schedules. Support for the control device time schedules shall be in addition to the BMS time schedules.

From the workstation or web workstation, it shall be possible to configure and download schedules for any of the controllers on the network.

Time of day schedules shall be in a calendar style and viewable in both a graphical and tabular view.

Schedules shall be programmable for a minimum of one year in advance.

To change the schedule for a particular day, a user shall simply select the day and make the desired modifications.

Additionally, from the operator web workstation, each schedule will appear on the screen viewable as the entire year, monthly, week and day. A simple mouse click shall allow switching between views. It shall also be possible to scroll from one month to the next and view or alter any of the schedule times.

Schedules will be assigned to specific controllers and stored in their local RAM memory. Any changes made at the workstation will be automatically updated to the corresponding

schedule in the controller.

It shall be possible to assign a lead schedule such that shadow/local schedules are updated based upon changes in the Lead.

It shall be possible to assign a list(s) of exception event days, dates, date ranges to a schedule.

Audit Trail

The workstation software shall automatically log and timestamp every operation that a user performs at a workstation, from logging on and off a workstation to changing a point value, modifying a program, enabling/disabling an object, viewing a graphic display, running a report, modifying a schedule, etc.

It shall be possible to view a history of alarms, user actions, and commands for any system object individually or at least the last 5000 records of all events for the entire system from Workstation.

It shall be possible to save custom filtered views of event information that are viewable and configurable in Workstation.

Web-based Operator Software
General:

Day-to-day operation of the system shall be accessible through a standard web browser interface, allowing technicians and operators to view any part of the system from anywhere on the network.

Graphic Displays:

The browser-based interface must share the same graphical displays as the Administration and Programming Workstations, presenting dynamic data on site layouts, floor plans, and equipment graphics. The browser's graphics shall support commands to change set points, enable/disable equipment and start/stop equipment.

Through the browser interface, operators must be able to navigate through the entire system, and change the value or status of any point in any controller. Changes are effective immediately to the controller, with a record of the change stored in the system database.

Alarm Management:
Systems requiring additional client software to be installed on a PC for viewing the web workstation from that PC will not be considered.

Through the browser interface, a live alarm viewer identical to the alarm viewer on the Administration and Programming workstation shall be presented, if the user's password allows it. Users must be able to receive alarms, silence alarms, and acknowledge alarms through a browser. If desired, specific operator text must be able to be added to the alarm

record before acknowledgement, attachments shall be viewable, and alarm checklists shall be available.

Groups and Schedules:

Through the browser interface, operators must be able to view pre-defined groups of points, with their values updated automatically.

Through the browser interface, operators must be able to change schedules – change start and stop times, add new times to a schedule, and modify calendars.

User Accounts and Audit Trail:

The same user accounts shall be used for the browser interface and for the operator workstations. Operators must not be forced to memorize multiple passwords.

All commands and user activity through the browser interface shall be recorded in the system's activity log, which can be later searched and retrieved by user, date, or both.

OPEN INTEGRATION

Any of the following Open Protocol Standards shall be used for integration of 3rd party devices or systems. In coordination with other system suppliers include the Open Integration protocols required to communicate with other systems. Refer to the drawings and documentation for the details of other systems to be integrated into the BMS.

BACNET (ANSI / ASHRAE 135)

The BMS system shall be capable of communicating to other building subsystems using the ASHRAE standard BACnet. The BMS shall be capable of acting as both a BACnet Operator Workstation and a BACnet Gateway.

An integrated BACnet Operator Workstation shall be provided which allows the monitoring of BACnet devices via data acquisition and control.

The system shall consist of one or more BACnet field buses with a minimum speed of 76.8kbps. The field bus layer supports up to 30 Standalone Digital Control Units (DDCs) for operation of HVAC and lighting equipment. These devices shall conform to BACnet standard 135-2007

The Network Router shall be capable of communicating as a BACnet over LonTalk, MS/TP device or as a BACnet IP device communicating at 10/100 Mbps on a TCP/IP trunk.

LonWorks

The BMS server shall provide a gateway for integrate the LonWorks Client Controllers.

Modbus

The BMS server shall provide an integrated interface to devices using the Modbus RTU

protocol, where the BMS server shall be the 'master' and the external device or system shall be the "slave". The BMS shall also support user definable data formats for Modbus devices to accommodate the wide variety of formats in use in the industry.

The system shall consist of one or more Modbus RTU (RS-485 or RS-232) field buses managed by the gateway Controller. The field bus layer shall consist of up to 250 DDC for operation of HVAC, power metering, and lighting equipment.

Data Exchange (if used on the project)
The BMS system shall have the capability to interface to the point database of other similar BMS systems (i.e. nodes) on a TCP/IP network. This shall enable both the acquiring of point data and issuing control outputs to other BMS systems.

Data Exchange with Microsoft Excel
The system must be capable of exporting bulk data to Microsoft Excel. As a minimum the following shall be supported:
Allow retrieval of data either periodically or snapshot
Allow retrieval of data via POINT.PARAMETER requests
Allow retrieval of tag names, descriptions etc
Allow retrieval historical data
Writing of values from Excel back to the supervisory system

Accessing the BMS from third party web pages
Web-page controls and a web server interface to the BMS shall be provided, which allow other users (up to 5 web users) to monitor & control a variety of BMS -supervised functions via their own Web pages created for their own Intranet or Internet and viewed from a standard web-browser. For example, it shall be possible for building manager to be able to view floor graphics, and to be able to monitor and control security information from outside of the project.

It shall be possible to limit web browser access to BMS facilities by means of standard web and networking techniques.

Paging and external annunciation of System Alarms

The BMS shall optionally provide a facility for sending alarm text from configured points to the following external systems:

Alphanumeric pagers

Digital mobile phones with text message (SMS) support

Email

SNMP message

Each point's paging priority threshold shall be individually configurable, and individually enabled or disabled. Each external device configured in the system shall have individually

selectable times and days of operation, an alarm priority threshold, and an alternative device for use in escalation of unacknowledged alarms.

Server Scripting Engine
The BMS system must have the ability to extend its functionality easily by the addition of small script code to certain server functions. This will enable additional customer specific functionality to be easily added to point, report and server processing. For example, a script shall enable a calculation to be performed and a number of points to be controlled based on another point going into alarm state. Scripts shall be able to be attached to point processing, report generation, server startup and shutdown, or executed on a periodic basis.

The scripting engine must support a standard scripting language such as Microsoft's VBScript. Access to the scripts shall be though an inbuilt scripting editor which provides key work support and syntax checking as well as an extensive range of online help including a large number of worked examples. Proprietary scripting languages shall not be acceptable.

DIAGNOSTIC CAPABILITIES

The BMS system must enable easy diagnostics of the health of the system. All diagnostic information shall be viewable through an easy to use user interface and shall be able to be easily exported as a stand-alone collection of material for later analysis. This information shall include the following:
Communications traces to selected controllers
All system log files
Details on system software installation
Application status information

It shall not be necessary to be an expert user in the system to gather diagnostic information.

DDC Sensors and Field devices

All field devices such as sensors, valves, etc. shall be provided from the same BAS supplier as a one source for manufacturing all control devices.

B. Temperature Sensors

1. All temperature devices shall use precision thermistors accurate to +/- 1 degree F over a range of –30 to 230 degrees F. Space temperature sensors shall be accurate to +/- .5 degrees F over a range of 40 to 100 degrees F.
2. Standard space sensors shall be available in an off white enclosure for mounting on a standard electrical box.
3. Where manual overrides are required, the sensor housing shall feature both an

optional sliding mechanism for adjusting the space temperature set point, as well as a push button for selecting after hours operation.

4. Where a local display is specified, the sensor shall incorporate either an LED or LCD display for viewing the space temperature, set point and other operator selectable parameters. Using built in buttons, operators shall be able to adjust set points directly from the sensor.
5. Duct temperature sensors shall incorporate a thermistor bead embedded at the tip of a stainless steel tube. Probe style duct sensors are useable in air handling applications where the coil or duct area is less than 14 square feet.
6. Averaging sensors shall be employed in ducts which are larger than 14 square feet. The averaging sensor tube must contain at least one thermistor for every 3 feet, with a minimum tube length of 12 feet.
7. Immersion sensors shall be employed for measurement of temperature in all chilled and hot water applications as well as refrigerant applications. Thermal wells shall be brass or stainless steel for non-corrosive fluids below 250 degrees F and 300 series stainless steel for all other applications.
8. A pneumatic signal shall not be allowed for sensing temperature.

C. Humidity Sensors

1. Humidity devices shall be accurate to +/- 5% at full scale for space and +/- 3% for duct and outside air applications. Suppliers shall be able to demonstrate that accuracy is NIST traceable.
2. As an option, provide a hand held field calibration tool that both reads the output of the sensor and contains a reference sensor for ongoing calibration.

D. Pressure Sensors

1. Air pressure measurements in the range of 0 to 10” water column will be accurate to +/- 1% using a solid-state sensing element.
2. Differential pressure measurements of liquids or gases shall be accurate to =/- 0.5% of range.

E. Current and KW Sensors

1. Current status switches shall be used to monitor fans motors less than 2000 CFM and non-belt driven. Current switches shall be available in solid and split core models, and offer either a digital or an analog signal to the automation system. Acceptable manufacturer is Veris or approved equal.
2. Measurement of three phase power shall be accomplished with a kW/kWH transducer. This device shall utilize direct current transformer inputs to calculate the instantaneous value (kW) and a pulsed output proportional to the energy usage (kWH). Provide Veris Model 6000 Power Transducer or approved equal.

F. Flow Sensors

1. Provide an insertion turbine flow meter for measurement of liquid, gas or steam flows in pipe sizes above 3 inches.
2. Install the flow meter on an isolation valve to permit removal without process shutdown.
3. Sensors shall be manufactured by Badger meter or approved equal.

G. Control Valves

1. Provide automatic control valves suitable for the specified controlled media (steam, water or glycol). Provide valves which mate and match the material of the connected piping. Equip control valves with the actuators of required input power type and control signal type to accurately position the flow control element and provide sufficient force to achieve required leakage specification.
2. Control valves shall meet the heating and cooling loads specified, and close off against the differential pressure conditions within the application. Valves should be sized to operate accurately and with stability from 10 to 100% of the maximum design flow.
3. Trim material shall be stainless steel for steam and high differential pressure applications.
4. Electric actuation should be provided on all terminal unit reheat applications.

H. Dampers

1. Automatic dampers, furnished by the Building Automation Contractor shall be single or multiple blades as required. Dampers are to be installed by the HVAC Contractor under the supervision of the BAS Contractor. All blank-off plates and conversions necessary to install smaller than duct size dampers are the responsibility of the Sheet Metal Contractor.
2. Damper frames are to be constructed of 13 gauge galvanized sheet steel mechanically joined with linkage concealed in the side channel to eliminate noise as friction. Compressible spring stainless steel side seals and acted or bronze bearings shall also be provided.
3. Damper blade width shall not exceed eight inches. Seals and 3/8 inch square steel zinc plated pins are required. Blade rotation is to be parallel or opposed as shown on the schedules.
4. For high performance applications, control dampers will meet or exceed the UL Class I leakage rating.
5. Control and smoke dampers shall be Ruskin, or approved equal.
6. Provide opposed blade dampers for modulating applications and parallel blade for two position control.

I. Damper Actuators

1. Damper actuators shall be electronic, and shall be direct coupled over the shaft, without the need for connecting linkage. The actuator shall have electronic overload circuitry to prevent damage. For power-failure/safety applications, an internal mechanical, spring return mechanism shall be built into the actuator housing. Non-spring return actuators shall have an external manual gear release to allow positioning of the damper when the actuator is not powered.

J. Smoke Detectors

1. Air duct smoke detectors shall be by BAS supplier. The detectors shall operate at air velocities from 300 feet per minute to 4000 feet per minute.
2. The smoke detector shall utilize a photoelectric detector head.
3. The housing shall permit mechanical installation without removal of the detector cover.
4. The detectors shall be listed by Underwriters' Laboratories and meet the requirements of UL 268A. or EN standards

K. Airflow Measuring Stations

1. Provide a thermal anemometer using instrument grade self-heated thermistor sensors with thermistor temperature sensors.
2. The flow station shall operate over a range of 0 to 5,000 feet/min with an accuracy of +/- 2% over 500 feet/min and +/- 10 ft/min for reading less than 500 feet/min.
3. The output signal shall be linear with field selectable ranges including 0-5 VDC, 0-10VDC and 4-20 mA.
4. AFMS shall be from Paragon Controls manufacture or equal approved.

EXECUTION

Documentation

As built software documentation will include the following:

1. Descriptive point lists
2. Application program listing
3. Application programs with comments.
4. Printouts of all reports.
5. Alarm list.
6. Printouts of all graphics
7. Commissioning and System Startup

Point to Point Checkout

Each I/O device (both field mounted as well as those located in FIPs) shall be inspected and verified for proper installation and functionality. A checkout sheet itemizing each device shall be filled out, dated and approved by the Project Manager for submission to the owner or owner's representative.

Controller and Workstation Checkout

A field checkout of all controllers and front end equipment (computers, printers, modems, etc.) shall be conducted to verify proper operation of both hardware and software. A checkout sheet itemizing each device and a description of the associated tests shall be prepared and submitted to the owner or owner's representative by the completion of the project.

System Acceptance Testing

All application software will be verified and compared against the sequences of operation.

1. Chiller control
2. Single Zone Air Handlers
3. Multi Zone Air Handlers
4. Packaged Roof Top Control
5. VAV Terminal Units
6. Fan Coil Control

Control loops will be exercised by inducing a set point shift of at least 10% and observing whether the system successfully returns the process variable to set point. Record all test results and attach to the Test Results Sheet.

Test each alarm in the system and validate that the system generates the appropriate alarm message, that the message appears at all prescribed destinations (workstations or printers), and that any other related actions occur as defined (i.e. graphic panels are invoked, reports are generated, etc.). Submit a Test Results Sheet to the owner.

Perform an operational test of each unique graphic display and report to verify that the item exists, that the appearance and content are correct, and that any special features work as intended. Submit a Test Results Sheet to the owner.

Perform an operational test of each third party interface that has been included as part of the automation system. Verify that all points are properly polled, that alarms have been configured, and that any associated graphics and reports have been completed. If the interface involves a file transfer over Ethernet, test any logic that controls the transmission of the file, and verify the content of the specified information.

TRAINING

The vendor shall provide onsite standard training for 2 days on all aspects of the system operation & maintenance.

CONFIGURATION SERVICES

The vendor shall supply all necessary configuration services including field controller configuration, database configuration, data entry, etc.

INSTALLATION SERVICES

The vendor shall provide installation services for the system including validation services if necessary.

Installation Practices for Field Devices

1. Well-mounted sensors will include thermal conducting compound within the well to insure good heat transfer to the sensor.
2. Actuators will be firmly mounted to give positive movement and linkage will be adjusted to give smooth continuous movement throughout 100 percent of the stroke.
3. Relay outputs will include transient suppression across all coils. Suppression devices shall limit transients to 150% of the rated coil voltage.
4. Water line mounted sensors shall be removable without shutting down the system in which they are installed.
5. For duct static pressure sensors, the high pressure port shall be connected to a metal static pressure probe inserted into the duct pointing upstream. The low pressure port shall be left open to the plenum area at the point that the high pressure port is tapped into the ductwork.
6. For building static pressure sensors, the high pressure port shall be inserted into the space via a metal tube. Pipe the low pressure port to the outside of the building.

Enclosures

1. For all I/O requiring field interface devices, these devices where practical will be mounted in a field interface panel (FIP). The Contractor shall provide an enclosure which protects the device(s) from dust, moisture, conceals integral wiring and moving parts.
2. FIPs shall contain power supplies for sensors, interface relays and contactors, and safety circuits.
3. The FIP enclosure shall be of steel construction with baked enamel finish; NEMA 1 rated with a hinged door and keyed lock. The enclosure will be sized for twenty percent spare mounting space. All locks will be keyed identically.
4. All wiring to and from the FIP will be to screw type terminals. Analog or communications wiring may use the FIP as a raceway without

terminating. The use of wire nuts within the FIP is prohibited.

5. All outside mounted enclosures shall meet the NEMA-4 rating.
6. The wiring within all enclosures shall be run in plastic track. Wiring within controllers shall be wrapped and secured.

Identification

1. Identify all control wires with labeling tape or sleeves using words, letters, or numbers that can be exactly cross-referenced with as-built drawings.
2. All field enclosures, other than controllers, shall be identified with a Bakelite nameplate. The lettering shall be in white against a black or blue background.
3. Junction box covers will be marked to indicate that they are a part of the BAS system.
4. All I/O field devices (except space sensors) that are not mounted within FIP's shall be identified with name plates.
5. All I/O field devices inside FIP's shall be labeled.

Location

1. The location of sensors is per mechanical and architectural drawings.
2. Space humidity or temperature sensors will be mounted away from machinery generating heat, direct light and diffuser air streams.
3. Outdoor air sensors will be mounted on the north building face directly in the outside air. Install these sensors such that the effects of heat radiated from the building or sunlight is minimized.
4. Field enclosures shall be located immediately adjacent to the controller panel(s) to which it is being interfaced.

HARDWARE MAINTENANCE

The vendor shall be able to provide hardware maintenance and spare parts support if required.

SOFTWARE ENHANCEMENT & SOFTWARE SUPPORT

The vendor shall provide a comprehensive software maintenance enhancement program for on-going support of the system.

39. TELECOMMUNICATION'S FUNCTIONAL (CLEAN) EARTH

Where specified and shown in the drawings, provide earth terminal bars(s) or disconnecting links for telecommunications functional earthing, which shall be bonded to a separate earth electrode.

Mount earth terminal bars(s) on insulated supports located at 300mm centre for 25mm bar and 450mm centre for 50mm bar, giving 50mm clearance at rear of bar. Mount all earth terminal bars(s) separately from other earth terminal bars(s). All such telecommunications earth electrodes shall be connected to the integrated earthing ring conductor at the nearest convenient place.

Install clean earth distribution in double insulated cables from an insulated main earth terminal to the equipment points.

Comply with the specified standards and regulations of relevant telecommunications providers.

Ensure the potential rise in telecommunications circuits due to power system earth faults is limited in accordance with BS 6701.

Telecommunications Reference Plain

Where specified and shown in the drawings, provide a reference earth plain network in telecommunications equipment rooms, in accordance with the regulations of the telecommunications provider. Provide separate earth electrodes connected to the integrated earthing system.

Testing and Commissioning:

Test and commission the system in accordance with, BSEN 62305, BS 7430 and BS 7671 and as specified.

Record all test measurements in accordance with - reference BSEN 62305.

The Contractor shall carry out the necessary tests of soil resistivity at selected points to the engineers approval to determine the suitability or otherwise of a proposed position for a main earth terminal.

Continuity and earth resistance tests shall be undertaken to the satisfaction of the Engineer when the installation has been completed.

Quality Control:

Handle, store, and install all equipment and components of the earthing system in accordance with the manufacturer's recommendations and BS 7430, BS 7671, BSEN 62305.

Inspect all equipment and components on delivery, before fixing and after installation and reject and replace any, which are defective.

Note: Tenderer shall provide with his offer complete design of the system, technical specification, catalogues, for earthing and lightning system, otherwise the offer will be technically rejected.

40. LV CONTRACTOR :

Scope:

Design, supply, installation and commissioning of the following scopes of work are to be separately contracted to one single specialised LV systems contractor:

40.1 Fire Alarm system for all Buildings

40.2 CCTV System
40.3 IPTV System and Satellite system
40.4 Telephone network **system and IP Telephone network**
40.4 Computer network with all required network cabinets, cables, ducts, data switch cables, etc
40.5 Access control system
40.6 Audio and visual system
40.7 Public address system

Minimum Requirements:

Specialist LV systems sub-contractor must,

a. be an ISO 9001 quality management system certified company.

b. must be a Kuwait Fire Department Class 1 certified company of Fire Alarm.

c. must be approved/registered at Ministry of Communication.

d. must have a minimum of 10 years of experience in low voltage systems.

e. must have stores/maintenance workshop locations.

f. must have an agency agreement with Fire Alarm and CCTV system.

g. must submit proof of successfully completing government contracts for last 5 years.

41. COMPUTER NETWORKS

Computer LAN:

41.1 Scope of Work

The scope covers design, supply, install, test and commission of a suitable architecture/layout of the proposed networking system, commissioning including successful completion of acceptance tests and any other services specified. A drawing showing LAN Network is enclosed as part of this tender document. As shown in this sketch, it is intended to offer a guideline and should be taken as an approximate for the project network. The scope of work will cover the following:

1. LAN networking with intelligent infrastructure which is capable of handling coverage network for data and video for desktop computers at new to be constructed buildings and connecting them to main server control rooms situated.
2. Design of IP addresses, setup and configuration. The IP addressing scheme shall be developed with the Client
3. All LAN security and configurations
4. A network management system for the LAN
5. Testing of LAN Cables after laying, terminations and ferruling at both the ends. All testing tools and instruments shall be brought by the bidder and taken back after the testing.
6. Connecting and testing IPCCTV, IP Telephone PBX, Building Automation System, Building Management System, Public Address system, Access Control system, IPTV system and Ethernet systems via multimode fiber optics for buildings connectivity, server rooms and for vertical indoor cabling.
7. Supply all required hardware, including but not limited to network cabinet, switches, racks, patch panels, server, faceplates, cabling, software licenses for server management, operations protection and file sharing and exchange, and any other hardware and software requirements.
8. Equipment furnished though they may not have been specifically detailed in the technical specification, shall be complete in every respect with all mountings,

fittings, fixtures and standard accessories normally provided with such equipment's and/or needed for erection, completion and safe operation of the equipment's as required to meet the intent of ensuring completeness, maintainability and reliability of the total system covered under this specification.

41.2 Main tasks and Responsibilities

The Bidder's responsibilities within this project are derived from the leading concept of full responsibility for setting fully operational systems on a turnkey basis. This includes:

- **Supply of hardware platform, cabling and software licenses:** Define the relevant infrastructure configuration and relevant communication interfaces, with that supply software license with 3rd party's licenses where relevant.
- **Design documents:** Construct system detailed design document, and include detailed documentation. Final version will be agreed with MEW engineers later in the process.
- **Implementation plan:** Offer detailed implementation time tables (MS Project based), with specifying task responsibilities and recourses, key milestones. The implementation plan should clearly show all dependencies between individual modules for every part of the project. Project plans for individual solutions may be prepared and presented separately.
- **Integration and processes:** Perform full integration of all systems supplied.
- **Recovery procedures:** Define and test system shutdown and up time after system crash, including data recovery and setup.
- **Documentation:** Provide Installation guide, User guide, and system operator guide for daily maintenance and operations and other relevant technical documentation.

The design, workmanship, material and finish of all equipment shall be of the highest quality and should be built for long service. The equipment shall be based on the latest technological developments and incorporate the best features available.

41.3 System Overview:

The data network is intended to provide a highly available and secure infrastructure, applications and services for data communication required by various systems throughout the facility. The new data network should be:

- Scalable
- Centrally Manageable
- Secure
- Cost Effective
- Highly Reliable

41.4 Design overview:

- The porject constitute new building at various sites, which are all to be connected independently through fiber optics and UTP Cat6A cabling, to nodes at server rooms.
- All buildings with fiber optic cabling required, there shall be through using two runs of 12 core multi-mode OM3 fiber optics.
- Intra connection between sub cabinets on each building to the workstations is considered with two runs of 12 core OM3 optical fiber cables.
- Each building to have sub cabinets to host the zone centers of the network at that building/floor.

41.5 Submittals for computer network and all other computerized systems:

The bidder must prepare and submit this proposal according to the following structure:

1. The bidder must submit a technical proposal with detailed description and the system designs.
2. The bidder must submit in his proposal detailed design block diagrams showing the all the network components and interconnection between buildings and systems, with node & connectivity details.

3. The bidder must provide complete data sheet for all equipment reflecting the model numbers, features, ratings, performance, power requirements, and dimensions.
4. Complete set of technical/operation and maintenance Manual
5. Cabling and wiring diagram. Network Documentation (on Paper and CD)
6. Shop Drawings including plans, elevations, sections, details, and attachments to other Work. Including dimensioned plans and elevation views of components and enclosures. Show access and workspace requirements. Shop drawings shall include mounting details for all racked equipment. Such details shall include all mounting brackets, hardware, and connections to the building

41.6 **As-Built Drawings, Manuals, and Catalogue for computer network and all other computerized systems:**

Before testing and commissioning of the systems, the contractor shall submit soft and hard signed sets of the following:

a. Routes of ducts & buried cables with full details and any detected underground utilities.
b. As-Built Drawings, schematics, wiring, etc. of all units.
c. Detailed description of equipment (count, manufacturer, model number)
d. Operation/Instruction/Service manual/s.
e. Part List Catalogue (where applicable).

f. Product certificates signed by manufacturer/agent as certified for installation of equipment and components certifying that products furnished to the Contractor comply with following requirements:-

i. Equipment is specified to establish a minimum level of performance
ii. The Contractor is informed that should a manufacturer's instruction and this specification be at variance the Contractor shall seek instructions from the supplier
iii. Provide cabling, all equipment and accessories needed for execution, in accordance with the plans and drawings and corresponding system diagram.
iv. Install equipment in accordance with manufacturer's instruction.

41.7 Warranty for computer network and all other systems:

- The hardware/Software supplied under the contract shall be free from all defects/bugs and upon written notice from MEW, the contractor shall fully remedy, free of expense all such defects/bugs as developed under the normal use of the said hardware/software.
- Should any inspected or tested goods fail to conform to the specifications, MEW may reject the goods and the contractor shall either replace the rejected goods or make alterations necessary to meet specification requirements free of cost to MEW.
- During the warranty period, the contractor will be responsible for support and liability of offered supplies to MEW, including but not limited to: servers, switches, spare-parts, hardware and cabling.
- All software products should be fully licensed and under support for the first 3 years of operation.
- All system components shall be manufactured by ISO 9001:2000 certified companies.
- The enclosures shall be included in the system warranty and covered for a period of five years.
- The cabling system shall be guaranteed products and performance for a period of twenty years. During this period, the warranty will cover installed components such a cables and connectors as well as the complete cabling system including labor.

41.8 Variation Quantities and Configuration:

- Equipment and capacity requirements are the best estimates currently available.
- The Client reserves the right to modify quantity and configuration requirements.
- The Contractor agrees to sell the Client the revised quantity of items at the unit price as stated in the RFP regardless of quantity changes.

41.9 Passive network specifications:

- All installation work must be carried out according to Ministry of Communications guidelines and procedures for installation of fiber optic cables.

- All cable and inner duct are to be protected and fully supported throughout its entire run.
- All system components of the entire cabling system will be of the same manufacturer in order to insure efficient operation, component compatibility and a single warranty covering the entire installation. This includes but is not limited to:
    - Fiber/Copper Horizontal distribution
    - Fiber vertical distribution
    - Cabinets and Racks
- The cabling system shall be guaranteed products and performance for a period of twenty (20) years. During this period, the warranty will cover installed components such as cables and connectors as well as the complete cabling system including labor.
- The enclosures shall be included in the system warranty and covered for a period of five (5) years.
- All components will provide identification markings that meet the requirements of standard ANSI/TIA/EIA 606-A.
- All system components shall be manufactured by ISO 9001:2000 certified companies and all packaging shall carry clear product identification in the form of a barcode.
- All products must meet European directive 2005/95/EC concerning restriction on the use of hazardous substances (RoHS).

41.10 <u>Cable Marking:</u>

After installation each cable and inner duct is to be permanently labeled at each end with a unique cable number. Labels shall be affixed to the cable/inner duct at every transition of a vault, hand hole, riser closet, or major pull box. In addition to labeling of I/Os, patch panels, switches for new connections for easy management and troubleshoot. All length markings are placed at five meter intervals. The actual cable length will be within ±3% of the marked length. All markings are in indented in permanent characters. The entire length of each cable shall be marked with the following items:

- Manufacturer name
- Year of Manufacture
- Running meter length
- Fiber Count
- Sequential Length Markings in Meters.

41.11 Cable Sheathing:

The Tenderer must include in the tender documents information detailing the design and performance of the sheath and jacket of the cables offered. The information should include:

- The material used as the outer sheath.
- The thickness of the outer sheath.
- Resistance to environmental stress cracking and thermal and ultraviolet radiation ageing, to demonstrate that the cable is adequate for at least 20 year service life time.
- Direct pressure resistance factor.

41.12 Core Design:

The tenderer is to provide details of the design of the cable. The documentation provided will include a cross section of the cable, nominating the materials used on the drawing and any other relevant information.

41.13 Environmental Conditions:

a. Temperature
    - Max. Ambient sun radiation temperature: 80*C
    - Max. Ambient shade temperature: 50*C
    - Min. temperature can be below freezing point on some nights.

b. Humidity: Max. Humidity: 98.5%

c. Dust

The LAN cabling system will have a star-type topology. Cabling architecture is based on the following principles:

- Horizontal distribution from the cross-connect facilities to the workstations will be done with a $Cat6_A$ four twisted-pairs cable wired to a RJ45 outlet.
- Vertical distribution and main indoor backbone network connection will be done with 12 core multimode OM3 fiber optic cables for computers.

41.14 <u>Excavation and Earth works</u>:

The contractor is advised that an excavation permit is required for all types of excavation at all areas. Likewise, no excavation works of any nature whatsoever shall be commenced by the contractor without the prior written approval of MEW.

Excavations shall be carried out as follows:

1. Hand excavation by using hand tools around existing utilities.
2. Excavation by machine excavator. As a rule, long section of the underground trench clear of buries services many be excavated by a machine excavator. Within 10m vicinity on either side of any underground services, the trench shall be excavated by hand for laying the cable.
3. The minimum width of the trench shall be 0.1m and depth 1m. In no case shall be width or depth of trench excavation be less than specified.
4. For asphalt cutting, the use of a compressor is permitted for excavation up to depth of 30cm only. All surfaces shall be restored to original or better condition by the contractor. Depths of over 300mm shall be hand trenched.
5. During excavation, all surfacing or foundation materials shall be carefully segregated from the soil. Any materials that are required to be reused during or after permanent reinstatement shall be carefully stacked.
6. The contractor shall support the sides of open trenches with either timber or sheeting where the depth of the trench is more than 1m because of the nature of the soil or proximity of other services make this necessary. The contractor shall not claim charges for any extra quantity of excavations that shall be necessary by his failure to provide adequate timbering.

7. Great care shall be taken by the contractor to avoid undermining or otherwise disturbing existing pipes, cables. If despite precautions, such as soil is disturbed, the services concerned shall be temporarily supported and the void filled with a concrete mixture at no extra cost to MEW.

41.15 Environmental Monitoring System:

The bidder has to provide a scalable solution with extensive environmental monitoring for the data center and cabinet enclosures at server rooms.

It shall have smart sensors so that the system administrator will have a clear picture of the condition within multiple parts of each enclosure. The system should measure the temperature between equipment providing early warning of a potential problem. As the load on servers, switches, and network equipment's varies does the heat output. It shall have the following features:

- It shall be rack mount, with minimum supports 16 external configurable sensors and eight digital input sensors.
- Monitor and manage server room environmental conditions.

41.15.1 Temperature Sensor

- Applications from 0ºC to 50ºC
- High resistance to external influences on the cable due to digital output signal
- Accurate to within ±2°F (±1ºC)

41.15.2 Humidity Sensor

- Applications from 20% to 80% relative humidity at temperatures between 0ºC and 50ºC.
- High resistance to external influences on the cable due to digital output signal
- Accurate to within ±5% relative humidity

41.15.3 Liquid Detection Sensor

- For warning of flooding
- Detects any conductive liquid covering at least 5/8" diameter and 1/8" deep.

41.16 User outlets:

Outlets are to be used to connect the user equipment to the network through a patch cord. The RJ45 modules shall meet the following criteria:

- Category 6A RJ45.
- Tool integrated connector. No use of external tool is needed to facilitate future intervention.
- Possibility of re-termination if a mistake is made by simply opening the connector.
- Temperature rating from - 40° C to + 70° C.
- Plastic: High-impact, flame retardant

The following solutions are not acceptable:

- Modules that cannot be re-connected in case of termination error.
- Modules that require an external tool.
- Folded metal casing that can cut and be dangerous for the technician.

41.17 Faceplates:

The modules will be integrated in faceplates with either of the following methods:

- A single faceplate accepting two RJ45 modules each, one port for LAN and other port for Integrated Building Management System (for Consumer Affairs Offices). The faceplates will be matched to the electrical outlets, and must have label holders. (a transparent cover that allows the placement of a machine printed label)
- An adaptor in “Mosaic” 45mm formats that allows placing the modules in standard faceplates of the same brand and modeling as the electrical outlets, in PVC trunking, or in floor boxes. Each adaptor MUST also have a label holder.

41.18 Horizontal Copper cable:

Copper cables shall be used for the horizontal distribution between the end sockets and the distribution unit. They shall meet the following criteria:

- Category 6A F/UTP.
- Impedance 100 Ohms.

- Class AE F/UTP according to the last edition of ISO/IEC 11801ed2: 2002, with tinned copper drain wire and plastic isolation member (spline).
- Low Smoke Zero Halogen jacket, meeting IEC 332-1 Fire resistance.
- Operating temperature - 20° C to + 60° C.
- All copper components used in the horizontal system will be of the same manufacturer and will all be Third Party Certified to Cat 6A components, permanent link and channel complying with ISO Standards.
- All dual outlets will consist of blade 6A Ports.

41.19 Category 6A Copper patch cords:

Category 6A copper patch cords are to be used to connect the workstations to RJ45 outlets, and allow for patching in the enclosures between patch panels and active devices. They shall meet the following criteria:

- Factory made. (hand crimping of cable is not acceptable)
- Minimum length of 1-m. and maximum length of 5m.
- Category 6A according to ISO/IEC 11801 2002 ed.2.
- Strain relief boot should be present on top of the plug to protect the latch from damage during moves and installation. It also avoids mechanical stress on the wires.
- Manufactured from stranded wires for longer flex-life.

41.20 Fiber cable:

As regards for all links less than 300m will be fiber optic (OM3), for links between 300m and 500mm it will be fiber optics (OM4), it is planned to use 50/125µm multimode (Laser Optimized) fiber optic cable, type, in order to certify the correct operation of 10GBase-S between each main cross connect and the intermediate cross connect that houses the network active equipment. All fiber cables will be fusion spliced to LC pigtails and adaptors must be provided with dust caps.

41.20.1 The fiber strands (OM3, OM4) shall meet the following criteria:

- Maximum attenuation at 850nm of 3dB/km or less.
- Restricted launch bandwidth at 850nm of 2000 MHz.km or more.
- Core diameter 50 µm ± 2.5
- Cladding diameter 125.0 µm ± 1.0
- Numerical Aperture 0.200 ± 0.015

41.20.2 The fiber cable (OM3, OM4) shall meet the following criteria:

- Permanent tensile strength minimum 500N
- Maximum installation load 1500N
- Impact resistance 20J
- Crush resistance 300N/100mm
- Operating temperature - 20° C to + 70° C.
- Low Smoke Zero Halogen jacket

For all links longer than 500m and/or outdoor links, then single-mode OS1 fiber will be used. All cables between buildings will be protected in non-metallic ducting. Direct burial or aerial methods are not accepted.

The cable must be armored and with sheathing to withstand directly applied long term crush loads without increase in optical attenuation for any fiber or any decrease in the integrity of the optical fiber cable over its designated lifetime.

41.20.3 Fiber jumpers:

Fiber jumpers are to be used to connect the active devices to the fiber backbone.

The optical jumpers are Duplex 50/125µm (LOMF) OM3 type with connectors adapted to the fiber cabinet and the active devices used. Fiber jumpers to be Duplex type, with a keying system to avoid connector mismatch. All fiber jumpers will include their individual attenuation test results from the factory. The connector shall have a pull-proof design that helps prevent accidental disconnects and helps to assure optimal performance of equipment**.**

Fiber jumpers will meet the following performance:

- Ultra Physical Contact (UPC) finish for single-mode: Insertion loss: 0.40dB maximum, 0.20 dB typical, Return loss: minimum 55db.
- Physical Contact (PC) finish for Multimode 50 micron: Insertion loss: 0.50dB maximum, 0.30 dB typical, Return loss: minimum 20db.

41.21 Patching connectivity for fiber connectors and adaptors

Fiber adapters will be LC duplex for all fibers. single-mode adaptors will be blue with ceramic alignment sleeves, multimode adaptors will be beige or aqua with phosphor-bronze alignment sleeves.

All fiber cables will be fusion spliced to LC pigtails of 1m length. All connectors and adaptors must be provided with dust caps. They will meet the following performance:

- Single mode:
    - Ultra Physical Contact (UPC) finish
    - 8.3 micron core
    - 125 micron cladding
    - Maximum insertion loss 0.40dB maximum, 0.20 dB typical
    - Minimum return loss: 55db
- Multimode:
    - Physical Contact (PC) finish
    - 50 micron core
    - 125 micron cladding
    - Maximum Insertion loss 0.50dB, 0.30 dB typical
    - Minimum return loss 20db

The following solutions are NEVER acceptable:

- Field polishing.
- Composite / Polymer ferrules.
- Mechanically splicing pigtails.

41.22 Intelligent patching connectivity for copper horizontal distribution:

The Intelligent Panel's one-button tracing feature allows to trace patch connections instantly. By pressing the button above one of the ports, LEDs light up at both ends of the connection, making moves, adds and changes faster and more reliable. The intelligent Patch System is able to detect any copper or fiber single plug insertion and also detects any partially completed connection/disconnections. It can alert the administrator to the pressing of a trace button, easing both security and management concerns. All Intelligent Panels in a rack or cabinet are connected to the intelligent Patch Controller via a panel bus, providing information on the status of every connector. This information is then available for real time management of the cabling infrastructure to safeguard the information flow.

The intelligent patch panels shall be used in the cross-connect facilities to connect the four-twisted-pair cables, fiber cables and their related outlet, to the active devices via patch cords and fiber jumpers. They shall meet the following criteria:

- Support 24/48 ports in one unit of space.
- Enable all possible combinations of the various types of cable (UTP, FTP, SFTP) mounted on the same panel by using various connector blocks/modules.
- Include a label holder on each block for easy marking for all cables and strands.
- Have a metal structure enabling it to be durably fixed to the uprights of the 19" chassis and assuring automatic grounding between RJ-45 connectors, the panel, and the 19" uprights of the enclosure.
- Include rear cable support with plastic cable guides to hold cable without need for cable ties.
- Include quick mounting system to mount the panel into the 19" rails without use of cage-nuts.
- The modular patch panel should also enable combinations of fiber optic cassettes, transceivers or Power over Ethernet (PoE) injector modules (available by the same manufacturer) to be mounted on the same panel by using connector blocks/modules.

- The fiber can be mounted in the copper patch panel provided that it is enclosed in a plastic cassette protecting the strands and allowing the splicing.
- They shall include all the appropriate cabling accessories (bend limiting clips for the cables and fiber jumper, cable-ties, label-holders, etc.), to ensure correct positioning of the fibers.

The following solutions are not acceptable for the connectors

- Modules that cannot be re-connected in case of termination error.
- Modules that require an external tool.
- Folded metal casing of the connector.
- Modules that use only a vertical pressure from the thumb to make the IDC connection.

The following solutions are not acceptable for panels:

- Lack of rear cable support.
- Use of cable ties to fix the cables.
- Lack of automatic grounding.

41.23 <u>Free standing cabinets:</u>

Free standing cabinets are the preferred choice to house the patch panels and the active devices in rooms where persons other than IT technicians have access. They shall meet the following criteria:

- 19” format.
- Height 42 rack units (or as specified in the bill of quantities)
- Width of 800 mm, and depth of 800 mm. Optional depth of 1000 for servers if needed.
- With polyester coating for resistance to corrosion and scratching.
- Fitted with a safety glass curved front door.
- With top and bottom 19” pre-cut entries. These allow the use of standard 19” brush type cable management panels for example.

- Fitted with 2 sets of 19" uprights, front and back, marked with the units and allowing depth adjustment. Perforations to be 9.5 x 9.5mm.
- Fitted with horizontal and vertical patch cord management on both sides. (Left and right, front only) This management must include plastic rings, 3 cutouts, as well as multiple brush feed-through for the patch cord excess.
- Fitted with lateral cable support on both sides. (ie. Cable tray or bars on the inside so that cables are never fixed to the 19" rails but on proper support)
- Have key lockable front door, back door, and side panels. The side panels must be removable without tools, but locked with the key.
- Automatic grounding on all metal panels. Grounding kits are not allowed for removable panels.
- Fitted with leveling feet.
- Fitted with 4 ultra-quiet, high air flow fans located on the roof and connected to a thermostat for maximum airflow and heat dissipation.
- Include 4 casters of minimum permissible load 350kg
- Fitted with 1 (one) shelf fixed on all four uprights with a quick fixing method without screws so that it can be moved easily. Minimum load rating 50kg.
- Fitted with a self-adhesive hard plastic document holder located on the side panel. Minimum dimensions 200mm height by 300mm width.
- Acoustically engineered to reduce noise by up to 80%
- Each server rack must have two 9 way power distribution boxes. The servers in each rack should have dual power supply features so that they can connect to the power distribution boxes.

41.24 <u>Wall mounted cabinets:</u>

Wall mounted cabinets can be used to house the patch panels and the active devices where full 42u cabinets would be excessive. They shall meet the following criteria:

- **19" format.**
- Height of minimum 4 units, maximum 10 units. According to needs.
- Width of 600 mm, and depth of 600 mm.
- Pivoting to allow easy access to the rear of the cabling. Pivoting system must be reversible to choose left or right pivot.
- Have key lockable curved security glass front door.
- Pivoting side panels that can be removed from the inside with the need for any specific tool.
- With polyester coating for resistance to corrosion and scratching.
- With a brush type cable entry located either top or bottom according to needs.
- Automatic grounding on all metal panels. Grounding kits are not allowed for removable panels.
- Fitted with one set of 19” rails in the front. Perforations to be 9.5 x 9.5mm.
- Include 1 fan connected to a thermostat.
- Fitted with a 6 way power strip in 19” format.
- Fitted with a closed hard plastic document holder located on the side. Minimum internal dimensions 300mm by 120mm.
- If the cabinet is free standing instead of fixed on the wall, it must include a set of 4 casters, minimum load rating 120kg.

41.25 <u>Enclosure Design:</u>

Enclosures should have a minimum 30% extra space after installation, including all active, servers and UPS in place. The minimum size allowed is 9u.

If there is a need for 2 free-standing enclosures together, they must:

- Be coupled with the manufacturer kit.
- Allow a proper path for patch cords to go from one to the other.
- Be designed as to minimize patching in between the 2 enclosures.

In general, the placement of the equipment should be as follows:

- The fiber connectivity to be located on top.
- The horizontal patch panels to be located in the lower half.
- The active equipment to be located between the fiber backbone and the horizontal patch panels
- The copper backbone to be located below the horizontal patch panels
- The power supply to be located in the lower rear of the cabinet.
- All equipment inside the cabinet must be 19" format, or place on a 19" tray.

41.26 Active Network Specifications

41.26.1 Edge Access Switch

To connect devices and equipment to the network using 10/100/1000Mbps Ethernet over copper and 10 Gigabit fiber links to the server switches; switches shall provide 10/100/1000 Mbps PoE Ethernet speed to devices and they should be capable of stacking technology multi-layer capable switches.

41.26.2 Each access switch shall provide the following minimum specifications:

- Should provide a stackable switch with 10/100/1000 PoE+ ports, 2 combination 1000Base-X SFP and 2x 10Gbps ports, and in some cases with SFP ports as indicated in bill of quantities.
- Must support IP Multicast
- Must support Layer 2/3/4 packet classification capabilities, which can be based upon physical port ID, MAC address, IP subnet, IP address, IP protocol type, IP Type of Service (ToS), differentiated services code point (DSCP), and TCP/UDP port
- Must support distributed link aggregation between multiple switches in a stack
- Must support redundant stack management
- Must support stack management via a single IP address
- Must support redundant power as an option
- Must support IEEE 802.1x User Authentication
- Must support MAC authentication
- Must support Web-based authentication

- Must support MAC Port Locking (Dynamic and Static)
- Must provide power supply and fan monitoring via SNMP
- Must support the following RMON groups: Statistics, History, Alarms, Events, Packet Capture/Filtering Sampling
- Must support per port static and dynamic policy
- Must support IEEE 802.1s Multiple Spanning Tree
- Must support IEEE 802.1w Rapid Reconfiguration of Spanning Tree
- Must support operating temperatures up to 50°C
- Must support a Lifetime Warranty that includes firmware upgrade, bug fixes, phone support and advanced hardware return

41.26.3 Network Management System

To administer and manage the LAN, the contractor shall ensure that all devices can be managed by the new NMS, that SNMP MIBs are available and that any licenses required are included

The Network management solution should manage wired network, and will be installed in the server rooms. The server will be connected to the switches using 10/100/1000 Mbps Base-T interface, the NMS should provide the following features as minimum:

- Must provide a system-level management tool and centralized management and remote management support for wired devices
- Must allow system-level operations such as device discovery, event management, logging and application maintenance to be performed centrally.
- Must include several purpose-built plug-in applications that are integrated to provide specific, value-add capabilities to the management system.
- Must provide the capabilities to modify, filter, and create your own flexible views of the network.
- Must allow for graphing or viewing in table format and multiple OIDs that are user selectable.

- Must provide a tool to find the physical location of systems and end users, and where they are connected, quickly and easily.
- Must allow scheduled events or tasks that the user can perform behind the scenes or schedule an event for another time in the future.
- Must provide a system wide deployment of VLAN configuration and monitoring capabilities.
- Must support secure https switch management
- Must support the ability to define policies once and enforced the policies automatically on the proposed wired devices.
- Must be able to deploy policies network wide with a single click.
- Must provide automated functionality to ensure that appropriate services are available to each user, no matter where they log on.
- Must support 802.1x, Radius and MAC authentication
- Must allow IT administrators to easily define a number of pre-configured network policies, and designate select personnel to activate/deactivate these policies as appropriate
- Must be easy to configure and deploy providing a simplified, point-and-click Web-based management application
- Must not require any end-user client or software agent
- Must support the ability to download firmware to single or multiple devices simultaneously.
- Must be able to schedule routine device configuration back-ups.
- Optional plug-in application must be available that intelligently interacts with advanced security applications to automate responses to security incidents in terms of identifying, diagnosing, containment and reporting.

42. INTEGRATED BUILDING MANAGEMENT SYSTEM

General:

The specification mentioned below are the minimum and guidelines to the contractor. However, the contractor should provide the latest configuration including the hardware and software available from the manufacturer at the time of approval such as advanced model, type, accuracy, etc.

The Engineering room shall accommodate IBMS workstations, CCTV recording facilities, central battery system workstation, fire alarm annunciator panel, mimic panel , servers, printers UPS and peripherals.

The system shall perform checks on data integrity of all data acquired from each device. If an invalid or time out response is received, the data shall be ignored and the system will record the transaction as an error. Communications statistics shall be displayed as standard on the system and shall also be available as part of the reporting system or custom displays.

Once a control device is configured and placed in service, the system shall automatically begin background diagnostic scanning of the device to ensure that

42.1 Description:

The IBMS shall serve as global facility management system.The system is intended to seamlessly connect devices for monitor and control throughout the building regardless of subsystem type, i.e. variable frequency drives, low voltage lighting systems, electrical circuit breakers, power metering and card access should easily coexist on the same network channel.

The Integrated Building Management System shall be a fully integrated flexible building management system which is configurable to user specifics and incorporating distributed control techniques and standard open communication networks. It must support large range of applications and features which enable the integration, monitoring and control of all technical building system. The system shall be implemented as an integrated, open solution,

which enables monitoring room connectivity through standard Building Operating System (BOS) interface

The system shall also provide a graphical, web-based, operator interface that allows for instant access to any system through a standard browser. The contractor must provide PC-based programming workstations, operator workstations and microcomputer controllers of modular design providing distributed processing capability, and allowing future expansion of both input/output points and processing control functions.
The Integrated Building Management System (IBMS) shall consist of Network Server/Controllers (NSCs),Routers , a family of Standalone Digital Control Units, Administration and Programming Workstations, and Web-based Operator Workstations. The system shall provide control, alarm detection, scheduling, reporting and information management for the entire facility, and Wide Area Network (WAN) if applicable.

Seamless integration is required with guaranteed interoperability for:

- Data sharing
- Alarm and event management
- Scheduling
- Trending
- Device and network management

42.2**Scope of work:**

Design, supply, install, label, test, commission, maintain and document Integrated Building Management System to cover whole project. Preliminary design shall be submitted with the offer.

All the designs shall be done by Manufacturer certified designer.

Wiring for cabling systems shall be carried out by a Specialist Contractor approved by the Engineer who has a design, installation staffs with at least 5 years' experience in Kuwait.

The IBMS contractor shall provide a points schedule showing each proposed connected point to the system. The points shall be arranged as schedules showing the points allocated on a plant by plant basis, the controller specification(s) selected and I/O capacity supplied. Any points schedule supplied with this specification shall be considered as supporting information only. The IBMS specialist shall be responsible for ensuring the correct allocation of points required for meeting the performance specification. The IBMS contractor shall include a further schedule summarizing the field hardware and indicate the quantities, types, manufacturer and duties of the devices. Where a system comprises more than a single network, a diagram shall be supplied with the tender showing the lay-out of the LAN's and interconnections

42.3 **Quality Assurance:**

E. **Applicable Standards**:

1) IEC 870-5-101

2) IEC 870-5-104

3) Other equivalent International Standards.

F. **Acceptable Manufacturers:**

All ISO 9001 and ISO 14001 certified Manufacturers, whose products have been in use for at least 10 years in Kuwait and shall be in the list of approved manufacturers of MEW. A valid certificate must be included in the tender document.

A list of manufacturers that should be followed if previous condition are fulfilled:

a) Siemens
b) Johnson control
c) Honeywell
d) GE
e) Bosch
f) Schneider
g) Coba
h) Lonix
i) Toshiba
j) Mitsubishi
k) ABB

42.4 Submittals:

- Product data – Submit manufacturer's specifications, performance data, installation and maintenance instructions.
- Fill up the relevant Technical Schedule.

System requirements:

A) BAS LAN Segmentation

The BAS shall be capable of being segmented, through software, into multiple local area networks (LANs) distributed over a wide area network (WAN). Workstations can manage a single LAN (or building), and/or the entire system with all portions of that LAN maintaining its own, current database. High availability configurations shall be integrated in the system design in order to ensure operation in critical environments.

a. System Expansion

The BAS system shall be scalable, modular and expandable at automation level of the system using the same software interface, and the same TCP/IP level and fieldbus level controllers. Systems that require replacement of either the workstation software or field controllers in order to expand the system shall not be acceptable.

Web-based operation shall be supported directly by the DDC and/or GUI at the PC management level.

b. BACnet DDC requirements:

The system shall consist of freely programmable native BACnet , The system shall consist of one or more BACnet over Lon field buses. Minimum speed shall be 76.8kbps.

The communication bus to be BACnet over lontalk at 76.8 kbps or 10/100Mbits over Ethernet IP

c. LonWorks DDC requirements:

The system shall consist of one or more LonWorks FTT-10A field buses managed by the Network Server Controller. Minimum speed shall be 76.8kbps. The field bus layer shall consist of up to 60 DDCs using peer-to-peer, event-driven communication for operation of HVAC and lighting equipment.

d. Multiple protocols:

The BMS shall allow communications with a wide variety of proprietary and third party control devices utilizing off the shelf driver packages. It shall support BACnet, LON, Modbus, KNX and OPC standards for open system communications. All Network Server Controllers must natively support the BACnet IP, BACnet MS/TP, LonWorks IP, LonWorks FTT-10, Modbus TCP, Modbus RTU (RS-485 and RS-232), and Modbus ASCII protocols

42.5 Product – Integrated Building Management System:

Integrated systems:

The Integrated Building Management System shall monitor the following parameters of all services and incorporate them in the IBMS project as minimum:

Mechanical Services:

Air Conditioning

Plumbing

Energy Management and optimization

Water leak detection system for all Raised Floors under buildings

Fire-fighting system

HVAC building automation

Electrical systems:

Generators and associated fuel systems

Automatic transfer switch

LT Panels, Main / Sub main Switchboards, Distribution Boards & Motor Control Centers (MCC)

Uninterrupted power supplies (UPS)

Maintenance Management of all Building Services equipment

Provisions for future Facility Management

IPCCTV

Lighting control system

Access control system for PV container

Public address system

Energy optimization system

Elevators

Central battery system

Breakers monitoring system in all MLTB, MSB, SMSM, MCC, DBs

Status only of devices and equipment related to Fire mode operation of the building. Fire Detection and Alarm system will operate independently, but it will be integrated to BMS to provide additional alarm status notification.

42.7.2Integration functionality:

Building Management and Security Systems, including building automation, lighting controls, access control, intruder alarms, video monitoring, fire alarms, central battery systems shall be integrated using the Integrated Building Management System (IBMS) as the integration platform, which shall provide functionality as described in the System Architecture.

Mechanical Services: Provide full functionality

Energy Management: Provide fully functional integration for monitoring purposes.

Electrical systems: Provide full functionality

Uninterrupted power supplies (UPS): Provide full technical diagnostic capabilities, automatic real-time notification to vendor of UPS failure, notification of impending UPS

shutdown on IBMS, coordinated, automatic IP and IBMS equipment shutdown on expiry of UPS battery autonomy time

The Security Management System : Provide status of the security system and accessibility to the security via TCP/IP interface.

Elevators: Provide alarm status notification of equipment and devices.

Fire Management System: Will operate independently, but it will be integrated to IBMS through BACnet /IP to provide additional alarm status notification of equipment and devices related to Fire mode operation of the building. Alarm screen with appropriate graphics and location of activated devices superimposed on relevant part of the building layout shall automatically appear on designated workstations and audible signal shall alert the operator. Integrated with operation for HVAC Controls, for relationship with smoke control systems.

Lighting Controls

Lighting of common areas of the building shall be controlled by smart control nodes, which shall be connected to LON field bus. Lighting controls shall be implemented as part of the integrated Building Automation system. Lighting groups in the common areas are on/off controlled (and/or dimmed) as follows:

- Using local push buttons (on/off, on/off/up/down, lighting scenes)
- On occupancy
- Based on illumination level (dusk)
- Time schedules

Lighting controls are integrated with building automation and security systems and connected to the central user interface through the Integrated Building Management System (IBMS).

Other Systems

Other systems shall enable integration to BOS, whenever applicable

42.7.3: System components:

The integrated building management (IBMS) shall provide standard connectivity to the control room, which shall be capable of providing advanced maintenance and security services. It shall be comprised of the following parts:

A. Automation digital controllers and sensors with the necessary quantity and types to meet the requirements of the project for mechanical and electrical equipment control. Each controller will operate completely standalone, containing all of the I/O and programs to control its associated equipment. Each BACnet protocol controller shall conform to the BACnet device profile B-AAC.

B. Communication network module

C. Main Server The Contractor shall furnish One Ethernet-based Network Server Controllers. The controller will connect directly to the Operator Workstation over Ethernet at a minimum of 100mbps, and provide communication to the Standalone Digital Control Units and/or other Input/Output Modules. Network Server Controller shall conform to BACnet device profile B-BC. In addition the BACnet router must support BBMD (BACnet Broadcast Management device) Network controllers that utilize RS232 serial communications or ARCNET to communicate with the workstations will not be accepted. The server controller shall be tested as Network Server Controller. It must have data backup battery in case of power failure for real time clock (10 years) lithium (field replaceable) and for SDRAM (one month) Alkaline (field replaceable).

The server should meet or exceed the following specifications:

- Mother board Intel, FSB≥ 1GHz
- Number of CPUs≥ 2, ≥ 8 core, speed≥ 3.0Ghz, word length 64bits, Cache memory ≥ 8MB per core
- RAM capacity ≥ 64GB DDR3 SDRAM, speed≥ 1333 MHz, expansion slots ≥ 16 slots
- Disk storage ≥ 10TB 15K rpm SAS 6Gpbs, hot plug, ≥ 8 bays, RAID 0-6
- Network interface: Dual 10Gb embedded Gigabit Ethernet card
- Monitor: 21" LED HD wide rack sliding monitor

- Graphic card ≥ 1GB, Integrated sound card, ≥ 4 PCIe G2 expansion slots
- Optical drive: Internal SATA interface, ≥ 24xDVD±RW
- USB ports: ≥ 3 ports 2.0
- Power supply: Dual, hot plug redundant power supply (1+1) ≥ 750W
- Sliding rails with cable management arm
- Windows based.

D. Computersrunning the standard workstation software developed and tested by the manufacturer of the network server controllers and the standalone controllers. No third party front-end workstation software will be acceptablewith the following specifications:

- Mother boardIntel, FSB≥ 1GHz
- CPU speed ≥ 3.6Ghz – Quad-Core, Cache memory ≥ 8MB L2
- RAM capacity≥ 4GB DDR3, speed≥ 1333 MHz
- Disk storage≥ 1TB SATA 7200 rpm
- IEEE 802.3ab 10/100/1000 Mbps
- 21" LED HD wide monitor
- Graphic card ≥ 1GB, Integrated sound card
- Internal SATA interface, ≥ 24xDVD±RW
- USB ports ≥ 6 ports 2.0 (2 front, 4 rear)
- ≥ 2 PCI expansion slots, ≥ 1 PCIe, ≥ 2 DIMM
- Operating system Windows based operating system

The integrated building management (IBMS) shall provide standard connectivity to the monitoring room, which shall be capable of providing advanced maintenance and security services. It shall be comprised of the following parts:

K. Automation controllers and sensors.

L. Communication network module

M. Main Server with a capacity to control and monitor all systems and services i.e. FA, FF, Electrical, HVAC etc. The server should meet or exceed the following specifications:

- Mothers board: Intel
- Motherboard FSB: ≥ 1GHz
- Number of CPUs: ≥ 2, ≥ 8 core
- CPU speed: ≥ 3.0Ghz
- CPU word length: 64 bits
- Cache memory: ≥ 8MB per core
- RAM capacity: ≥ 64GB DDR3 SDRAM
- RAM speed: ≥ 1333 MHz
- RAM expansion slots: ≥ 16 slots
- Disk storage: ≥ 10TB 15K rpm SAS 6Gpbs, hot plug, ≥ 8 bays
- RAID configuration: RAID 0-6
- Network interface: Dual 10Gb embedded Gigabit Ethernet card
- Monitor: 21" LED HD wide monitor
- Graphic card: ≥ 1GB
- Sound card: Integrated sound card
- Optical drive: Internal SATA interface, ≥ 24xDVD±RW
- USB ports: ≥ 3 ports 2.0
- Expansion slots: ≥ 4 PCIe G2 slots
- Power supply: Dual, hot plug redundant power supply (1+1) ≥ 750W
- Accessories: Optical mouse, keyboard, 19" LED DH monitor
- Rack rails: Sliding rails with cable management arm
- Operating system Windows based.

N. Computers with the following specifications:

- Mothers board: Intel
- Motherboard FSB: ≥ 1GHz
- CPU speed: ≥ 3.6Ghz – Quad-Core
- Cache memory: ≥ 8MB L2
- RAM capacity: ≥ 4GB DDR3
- RAM speed: ≥ 1333 MHz

- Disk storage: ≥ 1TB SATA 7200 rpm
- Network interface: IEEE 802.3ab 10/100/1000 Mbps
- Monitor: 21" LED HD wide monitor
- Graphic card: ≥ 1GB
- Sound card: Integrated sound card
- Optical drive: Internal SATA interface, ≥ 24xDVD±RW
- USB ports: ≥ 6 ports 2.0 (2 front, 4 rear)
- Expansion slots: ≥ 2 PCI slots, ≥ 1 PCIe, ≥ 2 DIMM
- Accessories: Optical mouse, Arabic Qwerty keyboard
- Operating system Windows based

O. Laser color printer with the following specifications:

Color Laser Printer A4 Size (Network): New, original & Branded only with 3 years onsite comprehensive warranty. The printer's technical specification shall meet or exceed the following as minimum:

- Print technology: Laser
- Print speed (Black): Up to 20 ppm
- Print speed (Color): Up to 20 ppm
- First page out (Black): ≥ As fast as 9.5 seconds
- First page out (Color): ≥ As fast as 9.5 seconds
- Print resolution (Black): 600 x 600 dpi
- Print resolution (Color): 600 x 600 dpi
- Network: USB 2.0, gigabit Ethernet 10/100/1000 Mbps

P. UPS: 10 kVA as minimum to operate the system in the control room for 24 hours, in case of power outage.

Q. LAN network

E. The Local Area Network (LAN) shall be either a 10 or 100 Mpbs Ethernet network supporting BACnet, Modbus, Java, XML, KNX, HTTP, and CORBA

IIOP for maximum flexibility for integration of building data with enterprise information systems and providing support for multiple Network Server Controllers (NSCs), user workstations and a local host computer system. The system shall be designed with a top-level 10/100 Ethernet network, using the BACnet/IP, LonWorks IP, and/or Modbus TCP protocol. A sub-network of DDCs using the BACnet/Lon, LonTalk FTT-10A, and/or Modbus RTU, KNX protocol shall connect the local, stand-alone controllers with Ethernet-level Network Server Controllers/IP Routers.

F. Web-Based Operator Workstations: The Contractor shall furnish licenses for minimum 10 concurrent web browser based users to the IBMS. Web-based users shall have access to all system points and graphics, shall be able to receive and acknowledge alarms, and shall be able to control set points and other parameters. All engineering work, such as trends, reports, graphics, etc. that are accomplished from the WorkStation shall be available for viewing through the web browser interface without additional changes. The web-based interface must conform to the B-OWS BACnet device profile. There will be no need for any additional computer based hardware to support the web-based user interface.

User Interface

Systems shall be accessed through the Building Operating System (BOS). The Software features actual screen shots have to be provided showing the required features. The workstation software shall use a familiar Windows Explorer-style interface for an operator or programmer to view and/or edit any object (controller, point, alarm, report, schedule, etc.) in the entire system. In addition, this interface shall present a “network map” of all controllers and their associated points, programs, graphics, alarms, and reports in an easy to understand structure.

The system shall enable a client-based User Interface for central monitoring of systems. Also, the operator interface shall also be fully available through a web browser. From a standard browser such as Microsoft’s Internet Explorer, an operator shall be able to perform all functions on the same standard and custom displays as

used in the standard operator interface. The browser interface shall provide login and security authentication in the same way as the standard operator interface.

The user Interface shall allow for at least the following:

- Alarm monitoring and alarm handling by multiple operators
- Fire alarms
- Alarms from electrical and mechanical systems, alarm management shall be part of the IBMS and based upon common facilities and procedures for all systems, SMS included with alarm priorities, alarm annunciation, alarm processing, logging and summary.
- System maintenance alarms
- Video monitoring
- Remote diagnostics, energy optimization and trending
- Setpoint adjustment
- Control optimization
- Trendingby allowing real-time or archived data to be trended in a variety of formats. In addition, trend data types shall be able to be combined to allow for comparisons between data e.g. current real-time data versus archived data. All trend configurations must be possible on-line without interruption to the system
- Remote diagnostics of system/devices
- Preventive maintenance
- Logs and reportingsupport a flexible reporting package to allow easy generation of report data. The reports provided shall include pre-configured standard reports for common requirements such as Alarm Event reports and custom report generation facilities that are configurable by the user
- User profile and role management
- Access rights management

The user interface shall be implemented as a client application, which includes an automatically adapting tree structure of the building, building's parts, individual spaces, different systems and parts of systems. The tree structure can be used for navigation through the system.

All systems connected to Building Operating System can be accessed through the same graphical user interface either locally through LAN or through the Internet. The client software can be installed to unlimited number of remote computers or laptops. The client software shall allow for remote Internet usage of several sites using the same client.

User Interface

Systems shall be accessed through the Building Operating System (BOS). The Software features actual screen shots have to be provided showing the required features. System must have main user interface as follows:

The system shall enable a client-based User Interface for central monitoring of systems. The user Interface shall allow for at least the following:

- Alarm monitoring and alarm handling by multiple operators
- Intruder alarms
- Fire alarms
- Alarms from electrical and mechanical systems
- System maintenance alarms
- Video monitoring
- Remote diagnostics, energy optimization and trending
- Setpoint adjustment
- Control optimization
- Peak load management
- Trending
- Remote diagnostics of system/devices
- Preventive maintenance
- Logs and reporting
- User profile and role management
- Access rights management

The user interface shall be implemented as a client application, which includes an automatically adapting tree structure of the building, building's parts, individual spaces, different systems and parts of systems. The tree structure can be used for navigation through the system.

All systems connected to Building Operating System can be accessed through the same graphical user interface either locally through LAN or through the Internet. The client software can be installed to unlimited number of remote computers or laptops. The client software shall allow for remote Internet usage of several sites using the same client.

The user interface shall show system views, floor plan views, trend view, alarm view and event log view per building and system layer. Any alarm shall be shown in red color in both graphical views and tree structure. Each alarm message shall include shortcut to relevant graphical system and floor plan view.

The user interfaces shall provide easy access to frequently needed functionality, such as lighting controls, temperature set-point modifications, alarms, and configuration of scenes and modes of the space. The same user interface functionality shall be usable through any device

with a browser.

System Archeticture

The system shall be implemented as an integrated, open solution, which enables monitoring and connectivity through standard Building Operating System (BOS) interface.

The System Architecture shall consist of four levels:

- Service Level
- Management Level
- Control Level
- Field Level

The system shall be completely modular in structure and freely expandable at any stage. Each level of the system shall operate independently of the next level up as specified in the system architecture.

The system shall be fully consistent with the latest industry standards. To enable efficient functional system integration and to provide maximum flexibility and to respond to changes in the building use, the system offered shall support the use of BACnet, LonWorks, Modbus, M-bus, Ethernet TCP/IP and Internet communication technologies.

Service Level

Service Level shall allow the systems to be connected without additional software to one or several workstations, for providing centralized remote monitoring, alarm and fault detection of connected building management and security systems.

The monitoring station shall be capable of accessing remotely the systems through a standard interface through the BOS platform. The standard connectivity shall enable providing advanced maintenance and security services, such as security alarm monitoring, maintenance alarm monitoring, remote diagnostics, main user capability, remote control and optimization of all systems, energy optimization, trending and reporting services.

Predefined alarms from connected sites – e.g. intruder alarms, dirty filter notifications or leakage alarms, for example – shall appear in the alarm list with a specified priority. Alarms shall be stored in the central database.

Remote diagnostics of site systems and devices shall enable proactive maintenance of technical systems, energy optimization and efficient management of the infrastructure. Centralized monitoring of all connected sites with main user capability shall enable e.g. set point changes, manual controls and camera controls by using the remote connection.

Management Level

Management Level shall provide a uniform view to all systems through the open Building Operating System (BOS) platform. All the systems - controls of cooling, ventilation and lighting, access controls, intruder alarms, fire alarms and IPCCTC systems etc shall be integrated with the BOS using device drivers.

The BOS shall offer at least the following common services to be used by all connected systems:

1) Alarms
2) Historical trending
3) Logs and reporting
4) User profile and role management

To ensure fault-tolerant system functionality, the Management Layer shall not be responsible for any controls. The critical control functionality is taken care of by the intelligence on the vontrol Layer. The Management Layer shall provide standard connectivity through the BOS platform with the Service Level, with capability to support very advanced maintenance and security services. The BOS software shall also be capable of acting as a gateway between systems conveying messages, for example, from IP or BACnet devices to Modbus devices and vice versa.

The BOS shall collect trends from defined points, collect and forward alarms from the systems. The BOS shall enable efficient management of user rights. The BOS shall be capable of forwarding alarms to mobile phones using SMS, local alarm printers or to Service Center. It shall be possible to browse the alarm history for reporting and statistical purposes.

The BOS shall include a structured XML object model of the building, its parts and spaces, its connected systems, system parts and effect areas of each system.

The BOS shall include an open interface for other applications to interact with the connected systems.

The network technology shall be based on the IT standards, such as TCP/IP, and be compatible with latest LAN/WAN technology. The BOS shall be capable of supporting current and future building management protocols through implementation of network interface drivers. The BOS shall be capable of current and future systems and devices through implementation of device drivers.

Control Level

The Control Level shall consist of a distributed network of smart controllers, which communicate to each other using a commonly known field bus as specified herein. Connectivity towards Management Level shall utilize standard TCP/IP protocol.

The controllers shall include all the intelligence of the system. All communication shall be event based real-time peer-to-peer communication. All controllers shall be capable

of operating autonomously independently of Management Layer. For example, all systems react to alarms on the Control Layer without interference from upper layers.
Each automation controller shall be capable of handling several different systems in parallel through flexible distribution of I/O points. Automation controllers shall function as autonomous units and form an intelligent system by communicating in real time.

Field Level

The Field Level shall consist of industry standard sensors and actuators, industry standard (wiegand) card readers and IP cameras.

Distribution of intelligence

The intelligence of the automation systems shall be distributed into Smart Control Nodes, which are connected to control network (LON). It shall be possible to integrate the systems on Control Level without interference of Management Level, according to System Architecture.
Communication between Smart Control Nodes shall be peer-to-peer communication via a Free Topology. All communication shall be event based. Nodes shall be intelligent modules, capable of operating autonomously independently of Management Level. For example, all systems must be able to react to alarms on the Control Level without interference from upper levels.
Field devices are connected to Control nodes using the common industry standards. Control nodes are placed to the nearest electric cabin, side of air-handling units or in separate cabins when adequate. All systems shall use the same control network cabling, which uses free topology to maximize flexibility for future modifications and to minimize the need for cables. Electrical design should utilize star topology for controlled loads to maximize flexibility for changes.

Installation

- The installation shall be carried out according to manufacturer's Installation and Safety Instructions, supervised by manufacturer's Specialist. The system shall be installed by specialist sub-contractor approved by MEW for SCADA works.

- The bid must include a diagram illustrating wiring to Photovoltaic system identifying each component, manufacturer and model number.
- The license of Integrated Building Management System application has to be permanent to show exact number of points to be measured (virtual and actual) and how many free points / parameters available for future growth.
- Real life simulation data has to be provided to test system prior to operating system.

Building Management and Security Systems

Building Management and Security Systems, including building automation, lighting controls, access control, intruder alarms, video monitoring, fire alarms, central battery systems shall be integrated using the Integrated Building Management System (IBMS) as the integration platform, which shall provide functionality as described in the System Architecture.

Building Autiomation

Building automation includes control and monitoring of cooling/heating system, ventilation system, pumps, tanks, lifts etc. All mechanical and electrical systems shall be monitored and controlled by smart control nodes connected to Local Operating Network (LON). Building automation systems shall be integrated with lighting controls, security systems and fire alarm system as specified in the System Architecture. Building automation shall be connected to the central user interface through the Integrated Building Management System (IBMS).

Distribution of intelligence

The intelligence of the automation systems shall be distributed into Smart Control Nodes, which are connected to control network (LON). It shall be possible to integrate the systems on Control Level without interference of Management Level, according to System Architecture.

Communication between Smart Control Nodes shall be peer-to-peer communication via a Free Topology. All communication shall be event based. Nodes shall be intelligent modules, capable of operating autonomously independently of Management

Level. For example, all systems must be able to react to alarms on the Control Level without interference from upper levels.

Field devices are connected to Control nodes using the common industry standards. Control nodes are placed to the nearest electric cabin, side of air-handling units or in separate cabins when adequate. All systems shall use the same control network cabling, which uses free topology to maximize flexibility for future modifications and to minimize the need for cables. Electrical design should utilize star topology for controlled loads to maximize flexibility for changes.

Lighting Controls

Lighting of common areas of the building shall be controlled by smart control nodes, which shall be connected to LON field bus. Lighting controls shall be implemented as part of the integrated Building Automation system. Lighting groups in the common areas are on/off controlled (and/or dimmed) as follows:

- Using local push buttons (on/off, on/off/up/down, lighting scenes)
- On occupancy
- Based on illumination level (dusk)
- Time schedules

Lighting controls are integrated with building automation and security systems and connected to the central user interface through the Integrated Building Management System (IBMS).

Access Control & Intruder Alarms

Access control system shall be integrated with building automation, lighting controls and other security systems using the Integrated Building Management System (IBMS) as the integration platform.

Access control shall be implemented with control nodes, electronic/magnetic cards and magnetic locks. Users can be classified so that they have access only to the spaces they are allowed to enter according to programmed time schedules. The access control system is connected to IBMS for full control and reporting, and integrated into the central user interface.

Intruder alarm system shall include perimeter protection and indoor surveillance. Monitored doors. Intruder alarms are seamlessly integrated on software level to access control, IP CCTV, lighting control and building automation. Granted access disarms the alarm zones automatically. In case of burglary the system gives an alarm, which is relayed through IBMS to monitoring room and/or to specified mobile phones.

Network Controllers shall connect access control and intruder alarm system with Management Level using an open interface utilizing TCP/IP protocol.

Network Controllers shall connect with up to 32 Interface Panels using RS-485 bus. The door/reader Interface Panels shall operate also autonomously with no connection to a Network Controller. Network Controllers shall buffer the offline transactions from Interface Panels when connection to the IBMS server is down and send the transactions when the connection is restored.

The Network Controller shall enable access control database with 500 card holders. The memory of the Network Controller shall be easily expandable to accommodate up to 1,000 card holders.

Interface Panels

The selection of Interface Panels shall include at least Door/Reader Interface Panel, Input Monitor Interface Panel and Output Control Interface Panel.

The Interface Panels shall connect with Network Controllers using RS-485 bus. Door/Reader Interface Panels shall have two reader interfaces utilizing standard Wiegand protocol. Depending on application, the panel can be configured to control two sets of separate doors with a reader and an exit button, or one door with two-side readers (entry/exit).

In addition to the two reader interfaces, the Door/Reader Interface Panels shall have the following inputs and outputs: door monitor input, exit button input, strike relay output, auxiliary relay output. Door/Reader Interface Panels shall be capable of indicating door forced and door held alarms also locally by using the internal beeper of the reader. Interface Panels shall have local inputs for tamper and battery failure for indications and alarms.

The Input Monitoring Interface Panel shall be used to interface e.g. magnetic contacts to indicate alarm events. The Input Monitoring Interface Panel shall include 16 supervised alarm inputs and 2 relay outputs.

Output Control Interface Panel shall be used mainly to control lifts. The Output Control Interface Panel shall have 12 relay outputs and 2 supervised alarm inputs.

It shall be possible to create complex I/O linking and rules between Network Controllers and Interface Panels.

Video Monitoring

Video monitoring shall be implemented with IP CCTV system. The video monitoring system shall be integrated to IBMS server so that the system shall start recording video stream upon triggering from intruder alarm system, access control, CCTV or any other system integrated to BMS.

The video monitoring system shall support IP cameras. Usage can be done both via video monitoring system's own User Interface and the integrated user interface of the IBMS.

In addition to the software based user interface, it shall be possible to additionally expand the operator workstation with hardware based keypad and joystick interfaced with the system.

Fire Alarms

Fire alarm system shall be integrated with IBMS for monitoring. Fire alarm system can be integrated either by

a) Using potential free contacts of Fire Alarm Panels connected to control modules.
b) Using system driver which gives alarm information on individual sensor level to IBMS. In both cases alarms are relayed to IBMS and shown in the integrated graphical user interfaces. Ventilation is shut down in the area concerned.

Other Systems

Other systems shall enable integration to BOS, whenever applicable

Installation

- The installation shall be carried out according to manufacturer's Installation and Safety Instructions, supervised by manufacturer's Specialist. The system shall be installed by specialist sub-contractor approved by MEW for SCADA works.
- The bid must include a diagram illustrating wiring to Photovoltaic system identifying each component, manufacturer and model number.
- The license of Integrated Building Management System application has to be permanent to show exact number of points to be measured (virtual and actual) and how many free points / parameters available for future growth.
- Real life simulation data has to be provided to test system prior to operating system.

43. IP CLOSED CIRCUIT TELEVISION SYSTEM (CCTV)

43.1 Scope of Work

The IP closed circuit television system (CCTV) is intended for Security and Operational automated visual surveillance and alarm notification and recording video and data for key indoor and outdoor areas and locations including cameras at the contact and remote stands.

The Security Video System shall be an IP network-based, fully distributed, digital video system. The system shall utilize Local Area Network as a transmission medium for video, configuration, as well as storage of all data. The system shall provide full video control at the guard room, with additional full selection capability at any point within the network from a workstation or a video console display. The Security Video System shall provide unlimited expansion capability for the addition or modification of video inputs.

Drawings showing IP CCTV Network is enclosed as part of this tender document. As shown in this sketch, it is intended to offer a guideline and should be taken as an approximate for the project network. The scope of work of the IP CCTV system shall include design, supply, installation, programming, testing and putting into operation with all system equipment (MATRIX, DBs, DVR, Monitors, … etc.), but not limited to following:

43.1.1 The main IP CCTV equipment.

43.1.2 The work station IP CCTV equipment in control room.

43.1.3 Camera Management offering powerful and efficient installation and management capabilities.

43.1.4 Installation of the system related wiring and accessories.

43.1.5 Locating multiple video products on the local network using standard network protocols.

43.1.6 Installation, testing and putting into operation of all the integrated software of the main and subsystems including the interfaces and sub-modules.

43.1.7 Setting the IP addresses, showing connection status and managing firmware upgrades of multiple video products sequentially or in parallel.

43.1.8 Equipment and devices shall be connected to provide integrated system in accordance with applicable codes.

43.2 **Submittals**

Submit the necessary complete sets of documentation indicating type, size, rating, style, catalog number, manufacturer's names, photographs and/or catalog data sheets for all items to ensure compliance with specifications. This documentation shall be subject to the approval of the Engineer and no equipment shall be ordered without his approval for all equipment and devices, which are shown on Drawings, Schedules and in Bill of Quantities.

43.2.1 Shop Drawings: Provide Shop Drawings showing equipment and device locations and connecting wiring of entire IP CCTV system, including riser diagrams. Shop Drawings shall include, but not be limited to, the following:

43.2.1.1 Complete one-line riser diagram(s) showing all equipment and the size, type and number of all conductors

43.2.1.2 Large scale drawing of the main IP CCTV equipment.

43.2.1.3 Large scale drawing of control panels, and other devices.

43.2.1.4 Provide programming instructions and installation manuals.

43.2.1.5 Complete description and data including UL listing, or equivalent, for all system components.

43.2.1.6 Complete sequence of operations and functions of the system.

43.2.1.7 Complete system wiring diagrams for components and interfaces to equipment provided by others.

43.2.2 Product Data: Submit manufacturer's technical product data, including specifications and installations for each type of IP CCTV equipment. Include standard or typical riser and wiring diagrams and operation and maintenance instructions for inclusion in the maintenance manual.

43.2.3 Maintenance Data: Submit maintenance data and parts lists for each type of CCTV equipment installed, including furnished specialties and accessories.

43.3 **Quality Assurance**

A. Manufacturer Qualifications: Manufacturing firms of the IP CCTV shall be regularly engaged in manufacturing of IP CCTV system of type, size and characteristics similar to those required for the project and whose products have been in satisfactory service in similar projects for not less than five years.

B. Installer Qualifications: Engage an experienced Installer who is a factory-authorized sales and service representative to perform the work of this section. The Installer firm shall have at least ten (5) years of successful installation experience of IP CCTV systems similar to that required for the project.

43.4 **As-Built Drawings**

43.4.1 During the construction of the system, the contractor shall put in writing all his remarks, during the progress of work, concerning any suggested alterations from the Shop Drawings in wiring routes, locations of equipment or devices which arise from coordination between the system and other activities.

43.4.2 No execution of alterations shall be allowed before receiving written approval from the engineer.

43.4.3 All alterations shall be registered and filled by the contractors and extra copies shall be submitted to the involved parties (Engineer, Project Manager, Site, etc.).

43.4.4 A complete as-built draft set of Drawings and equipment schedules shall be prepared fifteen (15) days after completion of work for approval of the engineer. The draft as built shall include all previously approved alterations.

43.5 **Guarantee**

The contractor shall guarantee the system for FIVE years of operation.

43.6 **Technical Description**

43.6.1 The IP closed circuit television system (CCTV) is intended for Security and Operations automated visual surveillance and alarm notification and recording video and data for key indoor and outdoor areas and locations including cameras at the

operations contact and remote stands, and for monitoring PV panels cleaning and washing at all Stores.

43.6.2 The IP CCTV system shall be looked to as a primary security system that is used for operational surveillance also, which can be only programmed and configured by the authorized security officials from the main IP CCTV workstation. Authorization to access the system resources shall be made in levels (Administrator, Manager etc.) as programmed.

43.6.3 The IP CCTV system server computers shall perform real time capturing of video pictures, compress and digitally record the camera pictures at real time rates of 30 image/sec. Adopted compression shall be non-proprietary encoding algorithms schemes that secure no visible degradation from PAL quality video.

43.6.4 All the IP CCTV system equipment shall be matching, interfaced and operating all together as an integrated system and allow for future extension in number of server computers, cameras and workstations.

43.6.5 The system will allow for adding the capability for communication on private networks, Intranet, and the Internet. The IP CCTV system shall include, but is not limited to the following:

1. Video Network Storage Unit.
2. Storage Expansion Unit.
3. Public Security Network Gateway.
4. Video Console System.
5. Video Monitoring workstation.
6. Intelligent joystick.
7. Monitors.
8. Fixed dome indoor IP cameras.
9. PTZ outdoor IP cameras.
10. Printers.
11. Outdoor cameras housing.
12. Any other accessories required for full system functionality and integration.

43.6.6 It shall provide programmable security and operational digital video management, monitoring, digital recording and report issuing functions for the project including the equipment and monitors at Security and Operations rooms.

43.6.7 The system shall utilize the project Ethernet LAN using TCP/IP, HTTP, HTTPS,

SSL/TSL, TCP, UPnP (SSDP), ICMP, protocols connectivity to provide communication between the system equipment with equipment located at security and operations rooms.

43.6.8 Color PAL based video and programmable IP Closed Circuit Television system (CCTV) shall perform video Security and Operational visual surveillance and alarm notification at key indoor and outdoor areas and locations. It shall provide security and operational digital and programmable management, monitoring and recording functions for the project. Automatic digital recording of live video scenes shall provide user activated, event activated, scheduled recording and video motion detection activation including related data.

43.6.9 The IP CCTV system shall utilize indoor and outdoor fixed and PTZ movable color PAL TCP/IP network based digital cameras. PTZ type cameras shall be controlled remotely for pan, tilt, zoom movements, focus adjustment and camera on/off. This will be done using appropriate software modules that run under the management main software platform and drive PTZ cameras as configured by main system server.

43.6.10 The CCTV system shall display automatically, the alarm related Visual indication, pop-up live image, email and event log and data of the detected events on selected workstations, as programmed and configured. It shall also activate recording and actions according to preset camera settings for automated actions. It will also allow viewing real time live video pictures and manually position PTZ cameras.

43.6.11 The IP CCTV main server computer shall perform interlocking and coordinate with the other security-related systems, if required using special interfacing modules as part of the software that runs the two systems to communicate and integrate the necessary functions through the project LAN using TCP/IP protocols. The IP CCTV cameras shall be centrally processed and managed and shall be located at positions to cover the intended fields of surveillance.

43.6.12 Alarm events triggered by motion detection, external input or according to a schedule speeds up recording on motion or on I/O alarm FTP image upload from camera.

43.6.13 IP CCTV system depends on the LAN network of project and the reliability of that network is a must for the IP CCTV to perform as required. The LAN should provide the necessary bandwidth and the quality of service the IP CCTV system contractor(s) requires taking into account that communications are mostly in real time.

43.7 **IP CCTV System Management and Security Software:**

43.7.1 System management and security software for network cameras & video servers must support unlimited cameras, locations, and users all interacting with recording tools and functionality through a common web browser. On Demand Encoding provides the ability to scale the recording of cameras on a single machine. Software must be extremely scalable. The Software enterprise solution is designed to allow all of these locations and cameras to be viewed and controlled without regard to location.

43.7.2 The IP cameras recording software is an IP-Surveillance software that works with network cameras and video servers to provide video monitoring, recording, security and event management functions. Users can record video continuously, on schedule, on alarm and/or on motion detection. Recorded video scenes can be searched by date, time and events. Clips of interest from different cameras can be exported as required. Remote viewing and playback are also possible with the use of a Web browser or the Camera Station Windows client.

43.7.3 Intelligent Video Sensors for Video Analytics: Up to 8 channels per video analytics service are available. These include:

1. Trip Zone
2. Left Object Detection
3. Removed Object Detection
4. Loitering Detection

43.7.4 The system management software shall perform but not limited to the following:

i. Viewing and Recording for unlimited cameras.
ii. Video Recording of limitless capacity with frequent archiving.
iii. VMD Motion Detection activated recording with speed-up on motion.
iv. Event Activated Recording.
v. SMART SEARCH functionality.
vi. Hourly to daily archiving with network support and multiple archiving possible per day.
vii. Live viewing for cameras, JPEG & MPEG4 video together on screen.
viii. Recordings for all cameras viewing.
ix. Hot spot Carousel viewing.

x. De-interlacing of images.

xi. Input/Output Event Control, manual event buttons, event list in recordings

xii. On-the-fly configuration changes while recording

xiii. Intelligent PTZ Control with 50 preset positions and multiple patrolling schemes

xiv. Pause PTZ patrolling, control it manually, then automatic return to patrolling schedule

xv. Combine PTZ patrolling and go-to-position on events.

xvi. PTZ zoom to marked rectangle and PTZ scanning, moving slowly from one position to another and with point-and-click control.

xvii. Joystick support

xviii. Advanced IPIX support with 'Quad Views' of all 360 degrees at the same time.

xix. Motion/Event Alerting via email or SMS messages.

xx. Export in JPEG, AVI, WAV and DB formats, Evidence CD, data encryption & logs, user notes, print reports.

xxi. The Camera Management System offers powerful and efficient installation and management capabilities. With this software, you can automatically locate multiple video products on the network using standard network protocols. Furthermore, you can set the IP addresses, show connection status and manage firmware upgrades of multiple video products sequentially or in parallel.

xxii. The control of the IP CCTV system shall be performed by the system main server computer system, which shall include the necessary hardware, and management and security software including interfaces for two ways TCP/IP communication with third party systems or databases that might be needed for integration purposes running on other Window based systems.

xxiii. A built-in Digital Video Virtual Matrix Switcher. The IP Video Security System shall support the ability to switch any camera in the system to any monitor in the system, either through a PC Keyboard/Mouse or a joystick controller to either an analog or VGA Monitor.

xxiv. The System Manager shall be capable of incorporating RSA 256 bit public/private key authentication in addition to custom bit public/private keys. The system shall be capable of authenticating any video produced by the encoder that originally

produced the stream, network storage unit that records the stream, and the operator who exported the stream, all with time/date stamped video.

xxv. The IP Video Security System based digital recording and monitoring system shall incorporate a fault tolerant architecture and shall include redundancy in critical areas of concern. Encoders, power supplies and Network Storage Unit / Storage Expansion Box power supplies shall be capable of redundancy. In addition, all Network Storage Units and storage boxes shall provide RAID 6 redundancy as a standard in case of any system failure.

xxvi. The System Manager shall manage rights and permissions for all devices, persons, and any system video or other data. The main administrator can set up separate users to view specific cameras for their locations only.

xxvii. The IP Video Security System shall be able to handle future expansion of an unlimited total capacity from what is shown in the drawings, including but not limited to cameras, monitors, alarm circuits and relay closures.

xxviii. The system shall be fully distributed in nature so that each system device can remain operational in a majority of modes without dependence on other devices.

xxix. Multiple users shall be able to view the same camera view or sequence simultaneously. The system shall utilize Multi-cast streaming video to allow multiple users to view the same video stream, though not necessarily synchronized with each other, without affecting the bandwidth of the network.

xxx. Advanced video compression in streaming from server to client gives better use of bandwidth.

xxxi. The IP Video Security System shall log all alarms and events in the System Manager database.

xxxii. Audit log in Remote Client on user activity by time, IP address and cameras.

43.8.7 **PTZ outdoor day & night IP cameras**:

Outdoor PTZ movable color CCIR PAL TCP/IP network based digital cameras. PTZ type cameras shall be controlled remotely for pan, tilt, zoom movements, focus adjustment and camera on/off. Each of the cameras having PTZ controls shall be

equipped with remote control digital module for remote operation from the central control. Transmission of power to cameras shall be through the signal cables. All outdoor cameras shall be equipped with automatic bright light limiter and light intensity control (CCD auto-iris or CCD with auto iris-lens). The cameras should meet or exceed the following specifications:

Image Sensor: 1/4" EXview HAD CCD

Lens: Auto focus with 36x optical zoom f=3.4mm wide to 122.4mm tele. F1.6-4.5 with Infrared corrected (Day/night)

Angle of view: 1.7 – 57.8°

Zoom: 36x optical and 12x digital, total 432 xs

Sensitivity Colour/ B&W: Color: 1.4 lx (F1.6; 1/50 s) B/W: 0.01 lx (F1.4; 1/3 s)

Shutter time: Auto.: 1/1 – 1/10,000 s Manual: 22 steps

Pan Range: 360º endless

Tilt Range: 0º - 90º

Max speed: Pan 360º/s, Tilt 360º/s

Video compression: Motion JPEG MPEG-4 Part 2 (ISO/IEC 14496-2), Profiles: ASP and SP, Digital compression up to 30%

Resolution: MJPEG: D1 (720 x 576) / VGA (640 x 480) / QVGA (320 X 240): max. 25 ips (PAL) MPEG-4: D1 (720 x 576) / VGA (640 x 480) / QVGA (320 X 240): max. 25 ips (PAL) H.264 : D1 (720 x 576) / VGA (640 x 480) / QVGA (320 X 240): max. 25 ips (PAL), QCIF, CIF, 2CIF, 4CIF.

Frame rate (NTSC/PAL): Motion JPEG: Up to 30/25fps at 4CIF, MPEG-4: Up to 30/25 fps at 2CIF

Video streaming: Simultaneous Motion JPEG and MPEG-4 Controllable frame

rate and bandwidth Constant and variable bit rate (MPEG-4)

Image settings: Compression levels: 11 (Motion JPEG)/23 (MPEG-4), Configurable brightness, sharpness, white balance, exposure control, backlight compensation. Overlay capabilities: time, date, text, custom logo or image De-interlacing (4CIF resolution)

PTZ Control: 20 preset positions, Guard tour, Control queue Security: Multiple user access levels with password protection IP address filtering, HTTPS encryption

Alarm management: Events triggered by built-in motion detection, external inputs or according to a schedule. Image upload over FTP, email and HTTP Notification over TCP, email, HTTP and external outputs, Pre- and post-alarm buffer of 9 MB per channel (approx. 4min. of CIF resolution video at 4 frames per second).

Connectors: Ethernet 10BaseT/100BaseTX, RJ-45 ,D-sub for RS-232 port4 alarm inputs, 4 outputs.

Processors and memory: CPU: ETRAX 100LX 32bit video processing and compression: ARTPEC-2

Memory: 32 MB RAM, 8 MB Flash Battery backed up real-time clock

Power: 24V AC or DC, max 25W

. Humidity 20 - 80% RH (non-condensing)

Supported protocols: HTTP, HTTPS, SSL/TLS*, TCP, SNMPv1/v2cv/v3 (MIB-II), RTSP, RTP, UDP, IGMP, RTCP, SMTP, FTP, DHCP, UPnP, ARP, DNS, DynDNS, SOCKS. More information on protocol usage

Housing: required.

43.8.10 **Outdoor cameras housing:**

A. For outdoor IP cameras, housings shall provide full protection for environmental conditions (dust, sun, rain, temperature, etc.) and shall include sun hood and shall house all attached accessories of the cameras including the lens.

B. Housing shall not cause any loss in quality or sensitivity of pictures.

C. Metal construction (aluminum) weatherproof housing shall be used with outdoor cameras having suitable length to house the camera with the lens and its accessories.

D. Weatherproof housing shall be with thermal isolation kit, window defroster front glass window, sunshield and automatic fan.

E. Weatherproof housing shall be equipped with suitable accessories to be fixed either on fixed bracket or on pan/tilt head.

F. Power supply of weatherproof housing shall be similar to the camera and PTZ head rating.

Housing shall comply with IP 66

G. Mounting brackets shall be used for fixed and PTZ cameras, sturdy and corrosion resistant and suitable for installation from the ceiling or against the wall.

1. Materials: Main body, bracket and sunshield: Aluminum
2. Fastenings, wall fixings and locking clips: Stainless steel
3. Window: Glass, Camera mounting board: Bakelite
4. Gaskets: Polyethylene and Neoprene
5. Finish: Polyester powder coating RAL 9002 30% gloss white/grey
6. Casing: Integral tamper proof wall bracket Weatherproof to IP66
7. Operating conditions: Ambient operating temperature: -20°C to+60°C

43.9 **Approved Manufacturers:**

The products of the following international companies should be considered:

- Siemens
- Funk works
- Hyundai
- Vicon

43.10**Installation**

A. Install the cabling Network, locating outlets draw-boxes, splitters, taps, sockets and cabling.

B. Install the CCTV system including all accessories.

C. Installation should be coordinated with the Construction Manager and Telecommunication subcontractor

43.8 **IP CCTV System Equipment**

The system equipment should meet or exceed the following specifications:

43.8.1 **The Network Storage Unit:**

It shall meet or exceed the following design and performance specifications:

- The Network Storage Unit will execute full real time management, monitor and recording of the captured pictures and on the recorded and compressed IP tagged pictures together with their related data. It will communicate with the other sub-server computers through the project LAN using Ethernet TCP/IP protocols.
- The Network Video Storage Unit shall be an integrated hardware and software platform that store all camera video recordings. It shall provide Recording Throughput up to 250 Mbps Meets Demanding Performance Requirements for Real-Time Video, Audio, and Data Applications
- The Network Storage Unit shall use RAID 6 parity with RAID level compact flash system drive across the storage drives to protect recorded data against a hard disk drive failure.
- The Network Storage Unit chassis shall be designed for video surveillance recording applications and encompass redundancy at all vital points:
    1. Redundant, hot swappable power supply modules
    2. Redundant, hot swappable system fans
    3. Hot swappable O/S drive
    4. Hot swappable CPU fans
- The Network Storage Unit shall have the capacity Up to 9.082 TB, expandable with Storage Expansion Unit Device.
- The Network Storage Unit shall use the SAS/SATA or SCSI protocol or higher Performance to support Storage Expansion Unit expansion boxes. Minimum up to seven storage expansion boxes can be connected to a Network Storage Unit to increase retention times.
- The Storage Expansion Unit boxes shall support a mechanism to daisy-chain storage boxes together through a mini-SAS cable or SCSI Cable. All enclosure management

and diagnostic messaging shall flow through SAS connector to host Network Storage Unit.

- The Network Storage Unit shall use distributed load balancing across other Network Storage Units configured in a storage pool and provide automatic network failover from any box to any other box. The duration of time between a unit failing and its associated cameras being equally distributed to remaining storage managers shall not exceed 90 seconds.
- The Network Storage Unit shall support a guaranteed recording throughput of 250 Mbps per storage device. This throughput shall be guaranteed under normal and error (RAID rebuild) conditions.
- The Network Storage Unit shall support any number of cameras so long as the maximum throughput required is less than 250 Mbps.
- The Network Storage Unit shall support continuous, scheduled, alarm/event (including analytics alarms), motion, and manual recording. Pre- and post-alarm periods shall be programmable up to the total capacity of the system.
- The Network Storage Unit shall support bookmarking and locking/unlocking of video content on the drives.
- The Network Storage Unit shall support an intelligent video grooming protocol that can reduce the frame rate of recorded video as the video ages. Administrators shall have the flexibility to determine whether to groom alarm video or leave it at its real-time level
- The Network Storage Unit shall have the ability to report all diagnostic events, including software status diagnostics to a centralized user interface.
- The Network Storage Unit shall be fully managed from a remote workstation, including the ability to configure settings and update firmware and software.

43.8.2: **Storage Expansion Unit:**

The Storage Expansion Unit shall meet or exceed the following design and performance specifications:

- The Storage Expansion Unit shall utilize the SAS standard to attach to a Network Storage Unit. The Storage Expansion Unit shall support the same RAID level and performance as its host recorder.
- The Storage Expansion Unit shall have 2 GB compact Flash Card and offer up to 9TB based on raw 72TB of useable video storage (depending on site location as per bill of quantities). It shall be possible to expand the video storage available for each recorder up to a total of 84 TB, using up to seven Storage Expansion Unit units connected to the host recorder.
- The Storage Expansion Unit shall support RAID 6 disk management across 12 hard disk drives to eliminate downtime caused by up to two hard disk drive failures. If a single hard disk drive fails, the RAID 6 implementation shall protect data from being lost. It shall feature a hot drive swap that automatically rebuilds the RAID 6 array when a new drive is installed.
- The Storage Expansion Unit shall use redundant power supplies and redundant hot-swappable fans. All maintenance, including replacing failed hard disk drives, fans, or power supplies shall be accomplished without the need to remove the unit from the rack or take it off line.
- All video shall be digitally signed before being written to the hard disk drives. Video authentication shall be verified on the system before being played back with the Security Video System video player.
- The Storage Expansion Unit should have hot swappable SATA or SCSI.

43.8.3: **Public Security Network Gateway:**

- **The Public Network Gateway shall deliver Video from the Security Video** System components to the Public Network, further it shall providing web browser access.
- The Public Network Gateway shall provide system information through Email and event messaging & compatible with Active Directory Networks, it shall transmit videos in MPEG-4 format & JPEG.

- The Public Network Gateway shall have minimum 2 Network Interfaces: Public and Private with 1 Gigabit Ethernet RJ-45 port (1000Base-T).

  Public Security network gateway should meet or exceed the following specifications: -

  (i) Processor: PowerPC
  (ii) Video including MPEG-4/JPEG
  (iii) Video streams: Up to 30 connections
  (iv) Video resolutions: CIF,2CIF, 4CIF
  (v) Network: G/bit Ethernet (1000Base-T)

43.8.4: **Video Console System:**

- The video console display shall be a high-performance with minimum Quad-Core CPU, multiple stream decoding units, shall convert multiple MPEG-4 streams into video signal to be viewed on a VGA or analog monitor.
- The video console display shall allow for up to 16, 32, 48, or 64 streams to be decoded and displayed simultaneously, and it shall allow for video to be displayed on NTSC/PAL composite, NTSC/PAL S-video, or VGA monitors. Every output option shall display a single image, four images (2x2), nine images (3x3), or sixteen images (4x4).
- The video console display shall provide a user interface to the Security Video system, the video console display shall allow a user to operate the system like a traditional matrix, using the joystick, and keypad to control the video display.
- The video console display shall provide full access to operations through user-friendly, highly intuitive, and semi-transparent on-screen menus displayed in a graphical overlay on the monitor screen. The video console display shall have on-screen PTZ, device playback, property controls, and alarm interface display.
- The video console display system shall allow for growth to accommodate more users by adding additional video console displays and keyboards and shall allow for the addition of monitors to decode additional video inputs without adding user workstations. The video console display shall allow for the installation of compatible

four-channel decoders to create a completely scalable virtual matrix, and it shall allow for multiple display views for live or playback cameras or devices.

The video console should meet or exceed the following specifications:

- Mothers board: Intel
- Motherboard FSB: ≥ 1GHz
- CPU speed: ≥ 3.6Ghz – Quad-Core
- Cache memory: ≥ 8MB L2
- RAM capacity: ≥ 4GB DDR3
- RAM speed: ≥ 1333 MHz
- Disk storage: ≥ 1TB SATA 7200 rpm
- Network interface: IEEE 802.3ab 10/100/1000 Mbps
- Graphic card: ≥ 1GB
- Sound card: Integrated sound card
- Video resolution: QCIF, CIF, 2CIF, 4CIF
- Optical drive: Internal SATA interface, ≥ 24xDVD±RW
- USB ports: ≥ 6 ports 2.0 (2 front, 4 rear)
- Expansion slots: ≥ 2 PCI slots, ≥ 1 PCIe, ≥ 2 DIMM
- Accessories: Optical mouse, Arabic Qwerty keyboard
- Operating system Windows based

43.8.5: **Video Monitoring workstation:**

The workstation shall meet or exceed the following hard ware specifications:

- Mothers board: Intel
- Motherboard FSB: ≥ 1GHz
- CPU speed: ≥ 3.6Ghz – QUAD Core
- RAM capacity: ≥ 8GB DDR3
- Disk storage: ≥ 1TB SATA 7200 rpm
- Network interface: IEEE 802.3ab 10/100/1000 Mbps
- Graphic card:≥ 1GB

- Optical drive: Internal SATA interface, ≥ 24xDVD±RW
- USB ports: ≥ 6 ports 2.0 (2 front, 4 rear)
- Accessories: mouse, Arabic Qwerty keyboard, joystick to control PTZ cameras, Dual link DVI outputs
- Operating system: Windows 64 bit compatible with IP CCTV management software.

43.8.6: **Monitors:**

- Flat panel display: LED
- Size: 23 inch diagonal
- Viewable screen size: 23 inch
- Resolution: 1600 X 1200
- Dot pitch: ≥ 0.26 mm
- Operating system: Windows OS
- Power: 220 VACS, 50/60 Hz
- Panel life: ≥ 50,000 hours
- Viewing angle (H/V): ≥ $178^{o}/178^{o}$

43.8.8 Fixed dome indoor day & night IP cameras:

Indoor fixed color CCIR PAL TCP/IP network based digital cameras with built-in 100Base-TX network interface. Transmission of power to cameras shall be through the signal cables. The cameras should meet or exceed the following specifications:

Image Sensor: 1/3" 1080p HD CMOS image sensor OV2715

Lens: C/CS with adapter, 1/3" Full HD Megapixel, F1.2 – F360 varifocal 2.8 – 8 mmmm, Direct Drive (DC) Auto-Iris, horizontal viewing angle: 35.8° – 100.1°focus range: 0.3 m to infinity, Infrared corrected (Day/night), 18X Zoom.

Effective pixel: 1920 (H) x 1080 (V)

Sensitivity Color/ B&W: Colour: 0.5 lux (F1.2) 50 IRE B/W: 0.3 lux (F1.2) 50 IRE

Video compression: H.264 / MPEG4 / MJPEG (Triple streaming), digital compression up to 30%.

Resolutions: 1920 (H) x 1080 (V), QCIF, CIF,2CIF, 4CIF

Frame rate: 720P, SXGA, VGA up to 30 fps

Automatic gain control: Yes

Video streaming: Simultaneous Motion JPEG , MPEG-4 and H.264 Controllable frame rate and bandwidth Constant and variable bit rate (MPEG-4)

Image settings: Compression levels: 11 (Motion JPEG)/23 (MPEG-4),Rotation: 90º, 180º, 270º,Configurable color level, brightness, contrast, exposure, white balance, fine tuning of behavior at low light .Overlay capabilities: time, date, privacy mask, text or image

Audio: G.711 Two-way mono audio; full duplex

Storage medium: SD card, up to 32 GB

Security: Firewall / 802.1x

Users 20 simultaneous users of which 10 with audio Unlimited users using multicast (MPEG-4) Alarm and event management

Connectors: RJ-45 for Ethernet 10BaseT/100BaseTX (PoE) Power connector (terminal block type) Terminal block for 3 alarm inputs, 1 output

Flash: 4MB / 8 MB Battery backed up real-time clock

Power: DC 12 V / AC 24 V / PoE , 5.5 W

Operating conditions: 0 - 50 ºC , humidity 0 - 80% RH , Storage temperature -20 to + 60°C

Supported protocols: TCP/IP, UDP, HTTP, HTTPs, SMTP, SNMP, DNS, DHCP, NTP, ARP, ICMP, FTPc, FTPs, DDNS, RTSP (RTP, RTCP), IGMP v3, UpnP, CIFS, NFS, IEC802.1x, ONVIF.

43.8.9 **PTZ outdoor day & night IP cameras**:

Outdoor PTZ movable color CCIR PAL TCP/IP network based digital cameras. PTZ type cameras shall be controlled remotely for pan, tilt, zoom movements, focus adjustment and camera on/off. Each of the cameras having PTZ controls shall be equipped with remote control digital module for remote operation from the central control. Transmission of power to cameras shall be through the signal cables. All outdoor cameras shall be equipped with automatic bright light limiter and light intensity control (CCD auto-iris or CCD with auto iris-lens). The cameras should meet or exceed the following specifications:

Image Sensor: 1/4” EXview HAD CCD

Lens: Auto focus with 36x optical zoom f=3.4mm wide to 122.4mm tele. F1.6-4.5 with Infrared corrected (Day/night)

Angle of view: 1.7 – 57.8°

Zoom: 36x optical and 12x digital, total 432 xs

Sensitivity Colour/ B&W: Color: 1.4 lx (F1.6; 1/50 s) B/W: 0.01 lx (F1.4; 1/3 s)

Shutter time: Auto.: 1/1 – 1/10,000 s Manual: 22 steps

Pan Range: 360º endless

Tilt Range: 0º - 90º

Max speed: Pan 360º/s, Tilt 360º/s

Video compression: Motion JPEG MPEG-4 Part 2 (ISO/IEC 14496-2), Profiles: ASP and SP, Digital compression up to 30%

Resolution: MJPEG: D1 (720 x 576) / VGA (640 x 480) / QVGA (320 X 240): max. 25 ips (PAL) MPEG-4: D1 (720 x 576) / VGA (640 x 480) / QVGA (320 X 240): max. 25 ips (PAL) H.264 : D1 (720 x 576) / VGA (640 x 480) / QVGA (320 X 240): max. 25 ips (PAL), QCIF, CIF, 2CIF, 4CIF.

Frame rate (NTSC/PAL): Motion JPEG: Up to 30/25fps at 4CIF, MPEG-4: Up to 30/25 fps at 2CIF

Video streaming: Simultaneous Motion JPEG and MPEG-4 Controllable frame rate and bandwidth Constant and variable bit rate (MPEG-4)

Image settings: Compression levels: 11 (Motion JPEG)/23 (MPEG-4), Configurable brightness, sharpness, white balance, exposure control, backlight compensation. Overlay capabilities: time, date, text, custom logo or image De-interlacing (4CIF resolution)

PTZ Control: 20 preset positions, Guard tour, Control queue Security: Multiple user access levels with password protection IP address filtering, HTTPS encryption

Alarm management: Events triggered by built-in motion detection, external inputs or according to a schedule. Image upload over FTP, email and HTTP Notification over TCP, email, HTTP and external outputs, Pre- and post-alarm buffer of 9 MB per channel (approx. 4min. of CIF resolution video at 4 frames per second).

Connectors: Ethernet 10BaseT/100BaseTX, RJ-45 ,D-sub for RS-232 port4 alarm inputs, 4 outputs.

Processors and memory: CPU: ETRAX 100LX 32bit video processing and compression: ARTPEC-2

Memory: 32 MB RAM, 8 MB Flash Battery backed up real-time clock

Power: 24V AC or DC, max 25W

. Humidity 20 - 80% RH (non-condensing)

Supported protocols: HTTP, HTTPS, SSL/TLS*, TCP, SNMPv1/v2cv/v3 (MIB-II), RTSP, RTP, UDP, IGMP, RTCP, SMTP, FTP, DHCP, UPnP, ARP, DNS, DynDNS, SOCKS. More information on protocol usage

Housing: required.

43.8.9: **Printers:**

Color Laser Printer A4 Size (Network): New, original & Branded only with 3 years onsite comprehensive warranty. The printer's technical specification shall meet the following as minimum:

- Print technology: Laser
- Print speed (Black): Up to 20 ppm
- Print speed (Color): Up to 20 ppm
- First page out (Black): ≥ As fast as 9.5 seconds
- First page out (Color): ≥ As fast as 9.5 seconds
- Print resolution (Black): 600 x 600 dpi
- Print resolution (Color): 600 x 600 dpi
- Network: USB 2.0, gigabit Ethernet 10/100/1000 Mbps

43.8.11 **Outdoor cameras housing:**

A. For outdoor IP cameras, housings shall provide full protection for environmental conditions (dust, sun, rain, temperature, etc.) and shall include sun hood and shall house all attached accessories of the cameras including the lens.

B. Housing shall not cause any loss in quality or sensitivity of pictures.

C. Metal construction (aluminum) weatherproof housing shall be used with outdoor cameras having suitable length to house the camera with the lens and its

accessories.

D. Weatherproof housing shall be with thermal isolation kit, window defroster front glass window, sunshield and automatic fan.

E. Weatherproof housing shall be equipped with suitable accessories to be fixed either on fixed bracket or on pan/tilt head.

F. Power supply of weatherproof housing shall be similar to the camera and PTZ head rating.

Housing shall comply with IP 66

G. Mounting brackets shall be used for fixed and PTZ cameras, sturdy and corrosion resistant and suitable for installation from the ceiling or against the wall.

1. Materials: Main body, bracket and sunshield: Aluminum
2. Fastenings, wall fixings and locking clips: Stainless steel
3. Window: Glass, Camera mounting board: Bakelite
4. Gaskets: Polyethylene and Neoprene
5. Finish: Polyester powder coating RAL 9002 30% gloss white/grey
6. Casing: Integral tamper proof wall bracket Weatherproof to IP66
7. Operating conditions: Ambient operating temperature: -20°C to+60°C

43.9 **Approved Manufacturers:**

The products of the following international companies should be considered:

- Siemens
- Funk works
- Hyundai
- Vicon

43.10 **Installation**

A. Install the cabling Network, locating outlets draw-boxes, splitters, taps, sockets and cabling.

B. Install the CCTV system including all accessories.

C. Installation should be coordinated with the Construction Manager and Telecommunication subcontractor.

43.11 **Testing**

A. The signal performance must satisfy system specification.
B. Installation should be coordinated with the Owner Representative Engineer.

43.12 **Warranty**

As per warranty specifications stated at Computer Networks clause.

43.13 **Submittals**

As per submittals specifications stated at Computer Networks clause.

44. IP TELEPHONE SYSTEM

44.1 Scope of Work:

MEW is seeking to conclude a contract that shall include design, supply, installation, configuration, testing, commissioning and maintenance and putting into operation with all required system of a logically and administratively single, resilient, scalable IP PABX telephone system, including but not limited to following:

- Endpoints and devices required to access any services provided
- Anything required for the solution to operate over the department IP data network, including any necessary configuration of the data network equipment.
- All conduits, conduit accessories, telephone cables, wires and other accessories, telephone terminal, cabinets, draw-in boxes, telephone cables outside the building.
- The telephone installations inside the buildings include supply, installation of all materials and Cat 6A or Fiber optic multi-mode OM3 (if necessary) cables conduits.
- Direct Telephone lines from the EPABX
- Extension telephone lines from the [EPABX]
- The telephone installation work outside the buildings includes supply and installation of necessary U.P.V.C pipes, U.P.V.C ducts and necessary hand holes with cast-iron covers.

44.2 Drawings:

The position of the telephone outlets indicated on the drawings are to be taken an approximate only and are intended to indicate generally the arrangement of the works. The exact position of telephone outlets shall be finally decided on the site. The contractor will not be allowed any extra payments for the same.

The contractor shall refer to all relevant civil, electrical and all other works drawings to ascertain for himself to the location and routes of all other services so as to maintain adequate clearance between telephones and other services.

The contractor shall be responsible for obtaining approval for all telephone drawings from Ministry of Communications before starting any installation.

44.3 Wiring:

The telephone cable Cat 6A or Fiber optic multi-mode OM3 (if necessary) shall be carried out with PVC conduits buried in walls and ceiling. Conduit should not be laid in voids provided for air conditioning ducts and for other services.

44.4 General requirements:

The work shall be as per the Regulations of Ministry of Communications and shall be to the satisfaction and approval of Ministry of Communications Engineer. The system described in the following sections is designed to support up to 300 users or extensions. Also, operating with E1 technology to provide Direct Incoming Dial (DID) and DOD (Direct Outgoing Dial) at end points.

- The bidder must have a clear understanding of Owner's technical environment including its structured cabling system.
- The bidder should not provide, throughout the contract, any equipment End-of-Sale (EoS), End-of-Life (EoL) and / or not Original. All Hardware, Software etc. (provided as spares or otherwise) must be new and original parts.
- The bidder will be responsible to make sure and report to MEW with evidential documents that all hardware and software operating before the ending date of the contract is the latest hardware platform running the latest release of the software as announced or released by the manufacturers.
- Software must be manufacturer original, legal and accepted by the ministry. The bidder will be required to provide a letter from the manufacturer confirming that the software is purchased and licensed for MEW directly by the bidder.
- The bidder must provide a Project Implementation Plan at the time of submitting proposal.

44.5 Communication Services:

The system must be suitable with adequate interfaces to provide a control of the communication processes and computer telephone integration (CTI). It should also be possible to set up the following functions or services:

- Unified Communication Solution
- Recording and analysis of call data and assignment to originator about all infrastructures
- Call center solutions
- Multimedia workflow solutions
- Integration of cordless phones according to DECT- standard.

44.6 Voice Messages and Fax

The system must support Voicemail and Fax services (as a part of unified messaging) to offer subscribers convenient interfaces for creating, receiving and managing messages. The subscriber should be able to:

- Listen to and manage voice messages by phone or speakers.
- New incoming voice messages should be notified to the subscriber.
- Ability for voice messages to be played paused or forwarded to another subscriber.

44.7 Attendants:

The system should support automated attendant which can be configured on the basis of rules and schedules. It should support up to 300 mailboxes with a recording capacity of 100 hours and should provide the below features:

- Live recording
- Voice to Email
- Central Voicemail box
- Message waiting indicator

44.8 Operator Console

A special configured telephone should be provided for the operator console. It should transfer all incoming non-DID calls and calls for which no users could be

reached (intercept calls) via the call allocation criteria. The attendant then routes these calls to the correct destination.

The following features should be available:

- Manage waiting
- Journal(Missed/Received /Outbound calls)
- Presence Status
- Outlook Contacts

44.9 **IP Addressing & VLAN Support**

- The solution should be able to provide easy addressing of the IP phones without having to change the addressing scheme of the existing IP data network.
- The IP phones should be able to share an existing Ethernet ports with data devices, without the need for additional Ethernet ports to be added by the customer to support voice
- To ensure the voice quality and secure the voice and data network, the vendor should support VLAN concept in the IP phones as well as 802.1Q trunking in the LAN infrastructure. Therefore a switch port in the IP phone would be required to simplify the user connectivity as well as support VLAN.
- The PC connectivity should be through the IP Phone. Therefore, the access switch must support separate VLAN assignment to the Data from the Voice VLAN. In this case PC connected to an IP phone would have a different VLAN from the IP Phone although they are both connected on the same LAN switching port.
- In terms of support for open industry standards, this is a list of what the end-to end solution including the intelligent network infrastructure should be able to support. If the standard is not currently supported, indicate in the “Availability Date” column when you expect to support it.

44.10 Technical Specifications:

The system being offered must be configured as a reliable, powerful and convenient IP communication system. It must be scalable and thus capable of meeting both

current and future requirements for the integration of voice communications in the IP-based system architecture.

The offered IP communication system must offer a comprehensive package of features for voice and data that support future-oriented and innovative communication solutions for IP infrastructures. The system must provide options to integrate a variety of communication services in a personal communications portal. This includes the following features, in particular, must be included as minimum:

- Support of Unified Communications applications by web based portal solutions
- Integration of mobile telephony
- Provision of voicemail services, and presence displays for all VoIP subscribers
- Coordinated set of functions across all applications
- Support for presence-based communication services and mobility functions based on a single-server solution
- Easy installation and convenient administration
- Open interfaces for the integration of external applications
- IP- Networking of more than one systems to a network solution

High usability combined with ease of use and support for convenient features are mandatory. The following function blocks must be supported:

- Calling, Dialing, Setting Up Connections
- Call hold and retrieve
- Day and time stamp for messages
- Call status per line (state, duration, number)
- Call waiting and retrieve
- Direct inward dial (DID) and direct outward dial (DOD)
- Directories—missed, placed, received calls list stored on selected IP phone
- Personalized voicemail and fax services (inbound / outbound)

- Immediate Divert to voicemail
- Hands-free, full-duplex speakerphone
- Last number redials
- Message waiting indication
- Mute capability from speakerphone and handset
- Music-on-hold
- Speed dial—multiple speed dials per phone
- Station volume controls (audio, ringer)
- Call Signaling, Calling Line ID
- Speeding Up the Communication Flow
- Conferencing
- Controlling Availability
- Easy Operation
- Call Distribution
- Security at the Phone
- Displaying presence information of the VoIP subscribers
- The Ability to route calls between devices such as mobile phone, office phone or other extensions within the organization
- Deployment of devices and applications across an IP network
- Clusters of IP-based PBX for scalability, redundancy, and load Balancing
- Configurable and default ringer WAV files per phone

44.11 Environment:

- The proposed IP PBX System shall operate in a normal office environment without special cooling requirements or built-in fans.
- The proposed IP PBX system should include UPS system with 4 hours back time

- The operating temperature and humidity range shall be at least between +5 to +40 with a relative humidity of 85%
- The supplier must state the heat dissipation from a fully loaded PBX System
- The supplier must state any special flooring requirements such as raised floor requirement or other mounting and cabling limitations.

44.12 Operator Console

A special configured telephone should be provided for the operator console. It should transfer all incoming non-DID calls and calls for which no users could be reached (intercept calls) via the call allocation criteria. The attendant then routes these calls to the correct destination.

The following features should be available:

- Manage waiting
- Journal(Missed/Received /Outbound calls)
- Presence Status
- Outlook Contacts

The IP PBX system and server should meet or exceed the following specifications: -

- Mothers board: Intel
- Motherboard FSB: ≥ 1GHz
- Number of CPUs: ≥ 2, ≥ 8 core
- CPU speed: ≥ 2.0Ghz
- CPU word length: 64 bits
- Cache memory: ≥ 8MB per core
- RAM capacity: ≥ 16GB DDR3 SDRAM
- RAM speed: ≥ 1333 MHz
- RAM expansion slots: ≥ 16 slots
- Disk storage: ≥ 2TB 15K rpm SAS 6Gpbs, hot plug, ≥ 8 bays
- RAID configuration: RAID 0-5
- Network interface: Dual 10Gb embedded Gigabit Ethernet card
- Monitor: 21" LED HD wide monitor

- Sound card: Integrated sound card
- Optical drive: Internal SATA interface, ≥ 24xDVD±RW
- USB ports: ≥ 3 ports 2.0
- Expansion slots: ≥ 4 PCIe G2 slots
- Power supply: Dual, hot plug redundant power supply (1+1) ≥ 750W
- Accessories: Optical mouse, Arabic Qwerty keyboard, 19" LED HD monitor
- Rack rails: Sliding rails with cable management arm
- Operating system Windows based.

44.13 <u>Terminal Devices</u>:

The IP terminals / digital TDM phones being offered must be easy to use via an intuitive dialog-oriented user interface. Functions that are frequently used by subscribers must be assignable to functional keys of the terminal device as required.

The IP Telephones must be embedded with high speed DSP's which allow a diversity of compression protocols to be supported as well as integrated 10/100 802.1q single port Ethernet switch, allowing the end user to plug a laptop or desktop computer into the phone directly in a serial fashion and saving RJ 45jacks. Power is supplied to the phones from a switch or Power Port on a Switch providing 802.3af – inline 48v DC power over Ethernet.

The offering must include a comprehensive product range of various IP-capable voice terminals, digital TDM phones, adapters to connect analog phones and PC-based soft clients. The standard functions for the terminals should include:

- Blind and unscreened call transfer
- Call pickup
- Toggle
- Consultation
- Call back on no answer
- Call back on busy

- Number redial
- Recall after going on-hook during consultation
- Do Not Disturb
- Call Waiting
- Call Forwarding
- Conference calls
- Weekday, date and time display
- Personal identification number (PIN)
- Enable/disable second calls

The main focus of proposed model of the phone‘s approach should be on:

- Best in class acoustics
- Usability / Ergonomics
- Innovative design, perceived value
- Security
- Serviceability
- Application support

The following will describe the different phone sets required by MEW. All IP telephone handsets provided should be capable of being inline powered and do not require a separate power supply for operation. The Contractors shall provide details of the types of phones proposed to be provided.

44.13.1 **Type A: Manager Level**

- Tiltable display: 6 lines, 240 x 128 pixels
- Backlit
- At least 5 keys with LED, e.g. Call Forwarding, Message waiting, Menu, Headset, Mute, Conference…
- Keys for Drop / Release, +/-, Redial
- Optical call alert with LED

- At least 6 free programmable keys with LED, 2 levels functionality
- 5-way navigator
- Headset jack for wired and wireless headsets
- USB slave
- Full-duplex Hands-free
- Volume adjustment

44.13.2 **Type B: Staff level**

Specification should include:

- Graphical display permitting intuitive operation of the phone
- Availability of audio keys for optimal configuration of the audio features available on the phone.
- Enhanced call features available including deflecting a call, call waiting, and transferring a call.
- Graphical display, 2 line monochrome
- 3 fixed function keys with LEDs
- 8 programmable keys with LEDs
- Control keys
- 3 navigation keys
- Volume adjustment

44.14 Approved Manufacturers

The products of the following international companies should be considered:

- Aastra, Sweden
- Siemens, Germany
- Mitel, Canada
- Alcatel, France

44.15 Warranty

As per warranty specifications stated at Computer Networks clause**.**

44.16 Submittals

As per submittals specifications stated at Computer Networks clause**.**

PART 2 - PUBLIC ADDRESS SYSTEM

Scope of work:

The Ministry of Electric & Water (MWE) intends to acquire complete public address system for its Ministry of Electric & Water new buildings project. The scope of work shall include design, supply, installation, configuration, testing, commissioning and maintenance and putting into operation with all required system equipment of the Public Address (PA) system and Back Ground Music (BGM) system, but not limited to following:

- System shall include complete equipment selection and distribution of the PA and Music/sound system. The system shall be of multi zones. The system shall function with sufficient sound levels in overcoming ambient noise levels ranging from 65 ~ 75 dB (SPL), assuring a uniform Sound level throughout the site.
- Music Sound System will cover all lobbies.
- Audio Public Address System Features:
    1. One-way paging by zone.
    2. Emergency paging override.
    3. Distribution of background music.

If there are any details or matters not specifically mentioned or shown, partially described or missing from the document which may be necessary to complete or perfect the work, then the Contractor shall include in the work.

The PA & BGM systems shall include:

- Audio cassette player
- CD Player
- AM/FM Tuner
- Power Amplifiers and control equipment.
- Ceiling Mounted Speakers
- Microphone with call and zoning station
- Zone selection unit
- Volume controls and pads.

- Mixer preamplifier
- System Rack with Monitoring and controlling system
- Microphone public address/music.
- Microphone paging system
- Digital receiver
- Servers

Approved list of manufacturers:

- Amperes
- PANASONIC
- BOSCH
- Philips
- Siemens
- Or any equivelant manufacturer approved by project engineer(s)

Products Description

The system equipment should meet or exceed the following specifications:

System Components:

A. Double Deck Cassette Player

The unit shall have high reliability with performance with the following requirement**:**

- Auto-reverse double deck system - A: play - B: play and record
- Auto-reverse function in play mode on both desks
- Auto-reverse recording on deck B.
- Input Impedance
- Audio output
- Alternate play
- Two speed dubbing
- Computer controlled movements
- Dolby B and C noise reduction systems
- Dolby HX-Pro dynamic range extension

Technical Specifications

Type 4-track, 2-channel double deck stereo cassette recorderwith vertical cassette loading

Heads 1 + 2

Tape speed 4.8 cm/sec. - 9.5cm/sec. (fast dubbing)

Frequency response 25 ~ 18.000 Hz ± 3 dB (with metal tape)

Signal / noise ratio >74dB (with Dolby C)

Channel separation >40 dB (at 1 kHz)

Multi CD player

The CD player shall combines excellent playback with ease of use and shall include the following:

- Change of CD during play
- Quick access to CDs by pressing the QUICK PLAY button
- Memorization of 40 tracks from different CDs in the desired sequence.
- Random play of the 8 CDs.
- Memorization of the recorded time and desired playback time in EDIT mode.
- Dolby noise reduction and HX-Pro

Technical Specifications

Type Multi CD player 8 CD loader carousel system

Frequency response 20 Hz – 20 kHz

Signal / noise ratio >95dB (1 kHz)

Dynamic field >90dB (1 kHz)

Channel separation >90dB (1 kHz)

Distortion 0.004% (1kHz)

Audio output 2 Vrms, ± 2 dB, 47 k

Digital Tuner

The tuner is an AM/FM frequency tuner that offers extremely stable disturbance-free reception, and has the following features:

- 16 storable FM stations.
- 8 storable AM stations.
- FM Stereo reception.
- FM free stereo reception.
- Manual or automatic tuning.
- Backlit liquid crystal display.
- Digital clock.
- Telescopic antenna for FM and loop antenna for AM.
- DNR (Dynamic Noise Reduction) circuit.
- Timers for tuner switch on/off.
- Adjustable output level.
- Possibility for remote control of the tuner functions.
- Mono and stereo outputs on RCA connectors.

Technical Specifications

FM tuner

Tuning range 87.5 – 108 MHz

Intermediate frequency 10.7 MHz

Sensitivity (S/N 30 dB) ≤10µV

Selectivity (+/-400 kHz) 60 dB

AM rejection ≥ 40 dB

Intermediate rejection ≥ 80 dB

Image range ≥ 25 dB

Stereo separation (1kHz) ≥ 25 dB

Stereo separation (1kHz) ≥ 30 dB

Frequency response 20 - 15,000Hz

Distortion (1mV –dev.40 kHz) ≤ 1%

Signal / noise ratio (1mV) ≥ 50 dB

Automatic tuning sensitivity ≤ 50 mV

Antenna provided Telescopic for interiors. 75 unbalanced

LF output voltage 500 mV

AM tuner

Tuning range 522 - 1611 MHz

Intermediate frequency 450 kHz

Sensitivity (S/N 20 dB) ≤1 mV

Selectivity (+/-9 kHz) 50 dB

Intermediate rejection ≥ 45 dB

Image range ≥ 30 dB

Distortion (5mV) ≤ 2%

Signal / noise ratio (5mV) ≥ 35 dB

Automatic gain control ≥ 45 dB

Automatic tuning sensitivity ≤ 2 mV

Antenna provided Loop for interiors

LF output voltage 300 mV

General Characteristics

Power supply 115/230 Vac (+/-5%) 50/60 Hz / 10 VA

Rack Control and Monitoring Unit

Control and monitoring unit for rack system, to insert on the audio chain between 6 sources and the power amplifiers. The LED VU-meter and built in monitor loudspeaker is to control the low level signal of six audio sources or the signal on the speaker outputs of six power amplifiers. Control both constant voltage and constant impedance speaker outputs. The output is to drive the power amplifier or amplifiers with one of the six sources that can be connected to the inputs. The AC OUTLET enables centralized switch on/off the equipment installed in the rack.

Technical Specifications

Type Control unit – Table – top

Source inputs/sensitivity 6 unbalanced inputs, on terminal strip/775 mV

Power amplifier inputs 6 balanced inputs, on terminal strip 100 V (standard)

70 V, 50 V, constant impedance (can be selected internally)

Output/voltage–Impedance Balanced, on terminal strip / 775 mV-600 W Max. Power controlled For constant impedance outputs

2000 W – 2Ω 1000 W – 4Ω

500 W – 8Ω 250 W – 16Ω

VU-meter sensitivity 775 mV (standard)

200 mV, 80mV (can be selected internally)

Max. current picked up (AC outlet) 8 A

Power supply /Consumption 115/230 Vac (+/-5%) – 50/60 Hz/10VA (without load on AC

outlet)

Pre-amplifier

The preamplifier shall have six universal XLR inputs with 24 Vdc phantom supplies. The system should have one balanced output, one tape output with level control and one auxiliary input. Graduated priority function for the universal inputs and multiple preamplifiers connected in cascade. The preamplifier should have the selection of priority type of input 1.

Technical Specifications

- Attenuation or exclusion of the other inputs.
- Override command output.
- Treble, medium, and brass tone controls. The power supply shall be in alternating current 230 Vac. Direct current power supply shall be 24 Vdc.
- Frequency Response : 50 – 15000 Hz (+/- 3 dB)
- Output / Voltage–Impedance: Bal. Out / 775 mV-600 Ω min
- Power supply: 115/230 Vac/24 Vdc
- Tone control: Bass –treble
- Volume control: master
- Input: RCA, un balancing, sensitivity odb/-2db
- Output: RAC –parallel out terminal

- Operation: Remote stand by control with LCD indicator
- Type: mono

Power Amplifiers

The Power Amplifiers should be specifically designed for the transmission of music programmers in all PA Systems; they shall have the following functions:

- "Input 1" balanced input on XLR connector and on terminal slip.
- Input 2" balanced / unbalanced input n RCA connectors and on terminal strip
- Possibility to give input 1 priority over input 2
- Adjustable gain on input 2
- Outputs for speakers at constant impedance (4W, 8W) and constant voltage 50-70-1000V
- Protection against fan breakage, overheating, overloads, and output short circuits.
- Auxiliary output for amplifier alarm indication in the event of malfunctions.
- Controls for treble, medium, and bass tones
- Parametric 6-octave Equalizer for medium tones
- Button for excluding the tone controls.
- "Fan Flt.", "Overheat", "Overload", "Signal", and "Peak" LED indications.
- Dual power supply in alternating current 115/230 Vac.
- Tone control: bass-treble

Technical Specifications

Power 1500 W RMS

Frequency response 50 – 15,000 Hz

Distortion ≤ 1%

Signal/noise ratio ≥ 85dB

Outputs / Voltage-impedance 25V – 50V – 70V – 100V - 4Ω

Voice / music & Zone control unit

The main functions of the control unit shall be remote controlled using the microphone stand with the following system configuration options:

- System with 10 audio zones covered by means of 10 amplifiers, one of each zone to use as a voice transmission and for music. The system makes it possible to choose in which of the 10 audio zones the background music is played normally ("Music on" buttons), and to select the zones in which the background music will be interrupted for a microphone announcement ("Speakers" button).
- System with 10 audio zones using a multi amplifier for voice/music. With this system, you can choose in which of the 10 audio zones the voice or music transmission will be made.
    - Control:
        - Master volume (front panel)
        - Treble tone control (rear panel)
        - Medium tone control (rear panel)
        - Base tone control (rear panel)

Technical Specifications

Type Relay switching unit – Rack mount

Input for amplifiers 2

Outputs for speakers (zones) 10

Max. power applicable to each

zone 100 V:500 W, 70 V 350 W, 50 V 250 W, 25 V 125 W

Speakers' relays 10 relays – max. contact capacity 5A

Alarm auxiliary relay 1 relay with 2 switching contacts – max. contact capacity 5 A

Override Command input 10-24 Vdc

Remote controls

General speakers relay control

Selective Speakers relay control

Alarm relay control

Auxiliary power supply output 24 Vdc-300 mA max

Power supply consumption 115/230 Vac (+/- 5%) 50/60 Hz / 10 VA

Power supply in direct current 24 Vdc

Microphone Station

The microphone stand shall be equipped with six “speakers” buttons used for selecting the audio zones in which a microphone announcement is to be made, interrupting the background music where present. When the stand is connected to high level input of the amplifier, the maximum distance shall reach 300 meters without any problems of disturbance or interference. By activating the alarm function, it should be possible to drive the amplifier with a two-tone siren signal incorporated in the stand. The audio cable has an auxiliary conductor for controlling the chime board of the amplifier, where present. The stand shall be permanently attached to the support surface.

Technical Specifications

Type Microphone desk stand for voice/music control unit

Directivity Unidirectional – cardioids

Microphone sensitivity 1.4 mV/PA

Output level High level: 0 dB (775 mV) – balanced Low level: - 42 dB (2 mV) – balanced

Output impedance High level: 600 Low level: 600

High level input sensitivity 0 dB (775 mV) – balanced

High level input impedance 50 k

Frequency response 250 – 15kHz

Distortion < 0.5%

Signal / noise ratio 80 dB

Power supply / consumption 24 Vdc – 50 mA

Digital Message Recorder Player

Provide a digital Recorder / Player to store and play emergency messages …etc both in Arabic & English languages with the following specifications:

- Display Digital
- Storage memory boards Max.14 as per message length Duration 42 sec to 20 minutes according to no. of Boards No. of messages Max 98.

Ceiling Speakers

Ceiling Speakers of white plastic fire retardant body equipped with a line transformer for constant voltage system having twin cone wide band low distortion, quick fitting of the holder ring and easy hooking system. Multi tapped transformer should also be supplied to make it possible to change the sound power produced.

Technical Specifications

Type Ceiling speaker with transformer

Nominal /Maximum Power 6/15 W (6 - 3 - 1.5 - 0.75 - 0.37 W)

Impedance: [100V]

1.6 kΩ – 6W, 3.3 kΩ – 3W, 6.6 kΩ – 1.5W, 13.3 kΩ – 0.75W, 26.7 kΩ – 0.37W

[50V]:420Ω – 6W, 840Ω – 3W, 1.6 kΩ – 1.5W, 3.3 kΩ – 0.75W, 6.6 kΩ – 0.37W

Frequency response 40 - 20,000 Hz

Sensitivity 93 dB (1 m/1 W)

Maximum sound pressure 105 dB (1 m/max power)

Input Voltage 50 / 100 V

Angle of Coverage [1000 Hz]:18, [2000 Hz]:100, [4000 Hz]: 50

Volume Control with Override facility

Attenuator Front panel in grey plastic, terminal strip for connection with override in case of general Announcement.

Technical Specifications

Type Constant impedance attenuator

Nominal power 10W

Input impedance 4

Output impedance 4

Controls Volume control with 5 positions + off

Attenuation 0, 6,12,18, 24 dB

Depth 50mm

Speaker wires and cables:

1.5 mm diameter copper conductor, 500 volt insulation, twisted pair covered with PVC jacket.

Rack Enclosure (42U).

As per specification in computer network LAN

Warranty

As per warranty specifications stated at Computer Networks clause.

Submittals

As per submittal specifications stated at Computer Networks clause.

PART 3 - AUDIO & VISUAL SYSTEM

Scope of work:

The scope of work shall include design, supply, installation, configuration, testing, commissioning and maintenance and putting into operation with all required audio visual system equipment. There are various types of systems depending on the type of areas, these systems not limited to following

- Audio systems, such as sound reinforcement, voice reinforcement, radio microphones, and surround sound system.
- Video systems, such as DVD recorders, VCR‘s, document cameras, TV tuners etc.
- Video teleconferencing systems.
- Display systems, such as projectors, screens and flat panel displays.
- Interactive devices such as whiteboards and writing tablets.
- Touch screen control technology and networked audiovisual control
- System connectivity through facility/connection panels and dedicated floor boxes.

Areawise Classification:

Theater

The following is an outline of the capabilities of a basic presentation system.

Image Display

- Primary image display system is Video Projection.
- Video projector is Ceiling Mounted on Motorized Lift.
- Projection screen is Ceiling Mounted Electric
- Table Recessed Motorized LCD Displays

Electronic Imaging

- Computer graphics from PC
- Laptop computer-based presentations
- Document. Camera/ Visualizer
- Table Recessed Terminal Pop up Boxes
- DVD Player

Audio Reproduction

- Audio CD playback from laptop computer
- Wall mounted Front of House speakers for audio reproduction
- Ceiling Recessed Reinforcement Speakers
- Infra Red Conference System

System and Environmental Control: Wireless Touch Panel

Voice Enhancement: Wireless Lavaliere and Handheld microphones

Meeting Rooms

Image Display

- Primary image display system is Video Projection.
- Video projector is Ceiling Mounted with Motorized Lift.
- Projection screen is Motorized Ceiling Mounted.

Electronic Imaging

- Computer graphics from PC
- Laptop computer-based presentations

- Document. Camera/Visualizer
- Table Recessed Terminal Pop Up Boxes
- DVD Player

Audio Reproduction

- Audio CD playback from laptop computer
- Wall mounted Front of House speakers for audio reproduction

System and Environmental Control: Wall mounted touch panel

Audio Visual Streaming: site wide

System and Environmental Control: Wall mounted touch panel control system

Voice Enhancement: Wireless Lavaliere and Handheld microphones

Products

MOTORIZED PROJECTION SCREENS

A. Type: Electrically operated projection screen for ceiling installation consisting of case, screen, motor, controls, electric brake, limit switches, mounting accessories, and other components necessary for complete installation.

B. Method of installation: Recessed ceiling mounted 10 mm diameter threaded steel suspension rods

C. Screen case:

1. Extruded aluminum housing with white paint finish and stamped steel end caps suitable for installation in return air plenums. Bottom closure panel forms slot for passage of viewing surface and is removable for access to operating mechanism and viewing surface. Bottom perimeter flange provides a trim around finished ceiling.
2. Housing designed with internal junction box and plug-in wiring connections to allow housing to be installed and connected to building power supply separately from motor and viewing surface.

D. Roller: 76 mm diameter steel or aluminum tube mounted on zinc plated brackets with double row radial ball bearings. Roller mounted on vibration insulators.

E. Viewing surface securely attached to roller at top and at bottom to weighted dowel.

F. Material: Matt white vinyl surface laminated on woven fiberglass base and surface is washable,.

G. Motor: 240 VAC, 50 HZ, 3 wire, instantly reversible, life time lubricated, and equipped with internal thermal overload protector, electric brake, and pre-set accessible limit switches. (flame resistant, and mildew resistant; Fiberglass Matt White Surface with a 5cm black border around Mounted inside screen roller on rubber vibration insulators).

H. Low voltage control: Control station [with 3 button switches for up, down and stop functions. shall be provided (in addition to touch panel control)

MOTORISED SCREEN: Screen Size – 102”

MEETING ROOM PROJECTORS

- Display 3 x 2.03 cm (0.8") p-Si LCD Panel with MLA (Aspect Ratio 4:3)
- Brightness 5000 ANSI Lumens (approx. 80% in Eco Mode)
- Contrast Ratio 600:1
- Native Resolution 1024 x 768 (XGA)
- Supported Resolutions 1920 x 1080 (HDTV 1080i @50/60Hz); 1600x1200 (UXGA); 1400 x
- 1050 (SXGA+); 1280 x 1024
- (SXGA); 1280 x 768 (WXGA) with Advanced AccuBlend™ Technology;1280 x 720 (HDTV 720p); 1152 x
- 900 (SGI. SUN); 1152 x 870 (Mac); 1024 x 768 (XGA); 832 x 624 (Mac); 800 x 600 (SVGA); 720 x 576, (SDTV 557p); 720 x 480 (SDTV 480p); 640 x 480 (VGA/Mac)
- Computer Analog Input: 1 x 5BNC, shared with Component Signal (YPbPr); Input: 1 x Mini Dsub
- 15-pin, compatible to component (YPbPr);
- Output: 1 x Mini D-sub 15 pin
- Computer Digital Input: 1 x DVI-D (with HDCP)
- Component Input: 1 x 3 RCA
- Video Input: 1 x RCA
- S-Video Input: 1 x Mini DIN 4-pin

- Audio Input: 1 x RCA Stereo for Video, S-Video and Component; Input: 2 x 3.5 mm Stereo Mini Jack for Computer analog and digital; Output: 1 x 3.5 mm Stereo Mini Jack (variable) for Computer 1, 2, 3 (DVID), Component,
- Video and S-Video
- PC Control Input: 1 x D-Sub 9 pin (RS-232) (male)
- Remote Control Input: 1 x 3.5 mm Stereo Mini Jack
- LAN 1 x RJ45, 10/100 base-T and W-LAN by Wireless LAN Module (removable)
- USB 1 x Type A (USB 2.0 high speed)
- Video Signals PAL/ PAL60/ NTSC/ SECAM/ NTSC 4.43/ PAL-N/ PAL-M

PC INTERFACES

Video

- Gain (0.7V p-p) Unity, (0.725V p-p) 50% peaking, (0.75V p-p) 100% peaking
- Bandwidth 300 MHz (-3dB)

Video input

- Number/signal type 1 analog RGBHV, RGBS, RGsB, RsGsBs
- Connectors' 1 15-pin HD female
- Minimum/maximum levels analog — 0.3V to 1.5V p-p with no offset at unity gain
- Impedance: 75 ohms RGB
- Horizontal frequency Auto scan 15 kHz to 130 kHz
- Vertical frequency Auto scan 30 Hz to 120 Hz
- Return loss -30dB @ 5 MHz
- Maximum DC offset 4.0V

Video output

- Number/signal type 1 analog RGBHV, RGBS, RGsB
- Connectors 6 BNC female 1 15-pin HD female local monitor buffered output
- Minimum/maximum levels Analog— 0.7V to 0.75V
- Impedance 75 ohms
- Return loss -30dB @ 5 MHz

Sync

- Input type RGBHV TTL (±), RGBS TTL (±), RGsB 0.3V (-), RsGsBs 1.3V (-)
- Output type RGBHV (±), RGBS (±), RGsB (-)
- Input level 2V to 5.5V p-p with ±0.2VDC offset (max.)
- Output level 4V to 5V p-p
- Input impedance 10 K ohms
- Output impedance 75 ohms
- Max. Propagation delay 48 nS
- Max. Rise/fall time 3.5 nS

Audio

- Gain unbalanced 0dB, balanced +6dB
- Frequency response 20 Hz to 20 kHz, ±0.05dB
- THD + Noise. 0.03% @ 1 kHz, 0.3% @ 20 kHz at rated maximum output drive
- S/N >90dB, at the rated maximum output (14dBu), balanced
- Stereo channel separation >95dB @ 1 kHz to 20 kHz

Audio input

- Number/signal type 1 PC level stereo, unbalanced
- Connectors 1 3.5 mm stereo jack, 2 channel
- Impedance >10 K ohms, DC coupled
- Maximum level +8.5dBu, (unbalanced) at stated %THD+N

Audio output

- Number/signal type 1 stereo (2 channel), balanced/unbalanced
- Connectors 1 3.5 mm captive screw connector, 5 pole
- Impedance 50 ohms unbalanced, 100 ohms balanced
- Gain error ±0.1dB channel to channel
- Maximum level (600 ohm) >+14dBm, balanced at stated %THD+N

MULTI GRAPHIC PROCESSOR

- Number/signal type 4 VGA-UXGA RGBHV, RGBS, RGsB, RsGsBs, RGBcvS, component video (interlaced or progressive),

- S-video, composite video, to 15 (configurable) component video (interlaced), S-video or composite video, single link DVI digital video (MGP 464 DI only), HD-SDI digital video, 2 single link DVI digital video (MGP 464 HD-SDI only)

Connectors

- Inputs 1-4 (4) x 5 female BNC (all models)
- female DVI-I (DI models only)
- female BNC, 2 female DVI-I (HD-SDI models only)
- Inputs 5-19 15 female BNC
- Resolution range 640x480 to 1920x1200, 480p, 576p, 720p, 1080i, 1080p
- Digital sampling 24 bit, 8 bits per color; 13.5 MHz standard (video), 162 MHz standard (RGB)
- Number/signal type 1 scaled RGBHV, RGBS, RGsB, HD YUV component video
- Connectors 5 BNC female, 1 DVI-I female
- Scaled resolution 640x4801,2,3,4,5,6, 800x6001,2,3,4,5,6, 852x4801,2,3,4,5, 1024x768 1, 2, 3, 4, 1024x852 1,2,3,4, 1024x1024 1, 2, 3, 1280x768 1, 2, 1280x1024 1, 2, 1360x765 1, 2, 1365x768 1,2, 1365x1024 1,2, 1366x768 1,2, 1400 x 1050 1,2, 1600 x 1200 1, 2
- Input type RGBHV, RGBS, RGsB, RsGsBs, RGBcvS, YUV
- Output type RGBHV, RGBS, RGsB, YUV
- Input standards NTSC 3.58, NTSC 4.43, PAL, SECAM, SMTPE 292M
- Input level 0.0 V to 5.0 Vp-p
- Output level 0.6 Vp-p for component video (tri-level sync)
- TTL: 5.0 Vp-p, unterminated for RGBHV, RGBS
- Input impedance. 510 ohms
- Output impedance 75 ohms
- Polarity Positive or negative (selectable)
- Serial control ports (1) RS-232 or RS-422, 9-pin female D connector (1) RS- 232, 2.5 mm mini stereo jack.
- Baud rate and protocol 300 to 115200 baud (default: 9600), 8 data bits, 1 stop bit, no parity.

- Ethernet control port 1 RJ-45 female connector.
- Ethernet data rate 10/100Base-T, half/full duplex with auto detect.
- Ethernet protocol ARP, DHCP, ICMP (ping), TCP/IP, Telnet, HTTP, SMTP

MATRIX SWITCHER/PROCESSOR

A. High performance processor for video and computer-video sources that shall allow the presenter to draw, point, or add text to electronic presentation materials using a touch screen monitor and/or a keyboard and mouse. It shall support all common analog and digital video and data formats, from composite video to high resolution DVI, RGBHV, S-video, and composite video signals

Video

- Routing Gain .Unity
- Bandwidth 600 MHz (-3dB), fully loaded
- Crosstalk -85 dB @ 1 MHz; -73 dB @ 5 MHz
- Switching speed 200 ns (max.)
- Video Input
- Number/signal type 8, 12, or 16 RGBHV, RGBS, RGsB, RsGsBs, HDTV, component
- Video, S-video, composite video

Connectors

- 12 x 5 BNC female
- Nominal level 1 Vp-p for Y of component video and S-video, and for composite video 0.7 Vp-p for RGB and R-Y and B-Y of component video 0.3 Vp-p for C of S-video
- Minimum/maximum levels Analog: 0.2 V to 2.25 Vp-p with no offset
- Impedance 75 ohms
- Horizontal frequency 15 kHz to 150 kHz
- Vertical frequency 30 Hz to 150 Hz

Video output

- Number/signal type 4, 8, 12, or 16 RGBHV, RGBS, RGsB, RsGsBs, HDTV, component video, S-video, composite video'

- Minimum/maximum levels 0 V to 1.8 Vp-p (follows input)
- Impedance 75 ohms
- Return loss -40 dB @ 5 MHz
- DC offset ±7 mV with input at 0 offset

Sync

- Input type RGBHV, RGBS, RGsB, RsGsBs
- Output type RGBHV, RGBS, RGsB, RsGsBs (follows input)
- Input level 0.5 V to 5.0 Vp-p, 4.0 Vp-p normal
- Output level AGC to TTL: 4.0 V to 5.0 Vp-p, unterminated
- Input impedance Inputs 1 to 4: 75 or 510 ohms, switchable Inputs 5 to 8, 12, or 16: 510 ohms
- Output impedance 75 ohms
- Max. input voltage 5.0 Vp-p
- Max. Propagation delay <120 ns
- Max. Rise/fall time 4 ns
- Polarity Positive or negative (follows input)

Audio

- Gain unbalanced output: -6 dB; balanced output 0 dB
- Frequency response 20 Hz to 20 kHz, ±0.05 dB
- THD + Noise 0.01% @ 1 kHz at nominal level
- S/N >105 dB, balanced, at maximum output (21 dBu), unweighted
- Crosstalk <-89 dB @ 1 kHz, fully loaded
- Stereo channel separation >-105 dB @ 1 kHz
- CMRR >-83 dB @ 20 Hz to 20 kHz

Audio Input

- Number/ Signal type 8, 12, or 16 stereo, balanced/ unbalanced.
- Connectors (8, 12, or 16) 3.5 mm captive screw connectors, 5 poles.
- Impedance >10k ohm, balanced/unbalanced, DC coupled
- Nominal level +4 dBu (1.228 Vrms)
- Maximum level +21 dBu, (balanced or unbalanced) at 0.01% THD+N

- Input gain adjustment -18 dB to +24 dB (default = 0 dB), adjustable per input by RS-232/422, Ethernet, or front panel.

Audio output

- Number/ signal type 4, 8, 12, or 16 stereo, balanced/unbalanced.
- Connectors (4, 8, 12, or 16) 3.5 mm captive screw connectors, 5 pole.
- Impedance 50 ohms unbalanced, 100 ohms balanced.
- Gain error ±0.1 dB channel to channel.
- Maximum level (Hi-Z)>+21 dBu, balanced or unbalanced at 1.0% THD+N.
- Maximum level (600 ohm)>+20dBm, balanced or unbalanced at 1.0% THD+N.
- Output volume range 0 to 64 (-75.8 dB to 0 dB) in 1 dB increments.

Control/remote — switcher

- Serial host control port 1 bidirectional RS-232 or RS-422, rear panel 9-pin female D connector.
- 1 bidirectional RS-232, front panel 2.5 mm mini stereo jack.
- Baud rate and protocol 9600 (default), 19200, 38400, 115200 baud (adjustable); 8 data bits, 1 stop bit, no parity
- Serial control pin configurations
- RS-232 9-pin female D connector.
- Mini stereo jack:
- RS-422 9-pin female D connector.
- Ethernet control port 1 RJ-45 female connector.
- Ethernet data rate 10/100Base-T, half/full duplex with auto detect.
- Ethernet protocol ARP, DHCP, ICMP (ping), TCP/IP, Telnet, HTTP, SMTP
- 1.24 MB nonvolatile user memory.
- Program control Control/configuration program for Windows®.

AMPLIFIERS

- Professional amplifiers with 105 dB SNR, and THD of less than 0.05%.
- Channel separation: >75 dB @ 1 kHz.

- CMRR: 75 dB @ 1 kHz (typical).
- Frequency response: 20 Hz to 20 kHz, ±1 dB.
- Input sensitivity: +4 dBu (1.23 Vrms).
- Class D Ripple Suppression that shall eliminate the high frequency switching ripple and EMI emissions.
- Convection cooled, fan-less operation that shall not require internal fans or vents for cooling, ensuring quiet, reliable operation making it ideal for rackmount applications.
- Automatic clip limiter that shall detect actual onset of clipping by comparing input and output waveforms designed protects the speakers.
- Multiple protection circuits that shall be activated during output shorts, thermal overload, or DC faults to prevent damage to the amplifier and speakers.
- Output Power: Amplifier power for wall mounted speakers shall be calculated considering required sound pressure level at the listener position to be 85 dB SPL and amplifier headroom of 3dB.

SPEAKERS (CEILING)

Power handling 16W

Nominal Impedance (transformer bypass) 8½

Sensitivity2 (at 1W @ 1m) 84 dB-SPL

Maximum SPL3 96 dB-SPL (pink noise @ 1m @ rated power) 102 dB-SPL (Peak)

Frequency range4 (-3 dB) 90 Hz – 16 kHz

Beam width (-6 dB point, average 1 – 4 kHz) 140° conical

100 Volt operations shall be used with the appropriate 100V amplifier.

WIRELESS MICROPHONES

Both, receiver and transmitter shall have 16 pre-programmed, free selectable UHF frequencies. The Auto Scan function shall enable automatic search for interference-free frequencies and fast and easy infrared transmission of the frequencies to the transmitter. They shall have 16 channels per frequency range and they can be operated simultaneously without any interference. Dual channel receivers shall be

used. The receiver shall display AF and RF levels while the transmitter shall warn when the batteries are getting weak.

Receiver:

- Operating principle: True diversity receiver (UHF)
- Frequencies: 16 pre-programmed frequencies
- Frequency ranges: 774-798 MHz, 790-814 MHz, and 841-865 MHz
- Antenna connection: 2 x TNC
- Nominal deviation: ± 40 kHz
- Output level: 1.2 V
- Signal-to-noise ratio: > 105 dB(A)
- T.H.D.: < 0.5% at 1 kHz
- Squelch Adjustable

Handheld transmitter:

- Transducer type: Dynamic
- Polar pattern: Hypercardioid
- Frequency ranges: 774-798 MHz, 790-814 MHz, and 841-865 MHz
- Frequency response: 55 - 18,000 Hz
- Modulation: FM
- Nominal deviation: ± 40 kHz
- Radiated transmitter power: > 10 mW
- Transmission range: > 100 m
- Signal-to-noise ratio: > 105 dB
- T.H.D.: < 0.5% at 1 kHz
- Operating time: >20 hours with two 1.5 V AA battery

Lavaliere Microphone:

- Transducer type: Condenser (electret)
- Frequency response: 25 - 20,000 Hz
- Polar pattern: Omnidirectional
- Max. SPL at 1 kHz: 120 dB
- S/N ratio: 60 dB

Pocket Transmitter

- Modulation FM
- Nominal deviation ± 40 kHz
- Radiated transmitter power>10 mW
- Sensitivity 10 mV - 0.3 V, adjustable
- Transmission range > 100 m
- Signal-to-noise ratio > 105 dB
- Operating time: >20 hours with two 1.5 V AA battery

DOCUMENT CAMERA

The document cameras shall be of the highest quality with high end components used for Camera Lens/Image Sensor (CCD)/Electronic Hardware/Software (Firmware) & Light System. Perfect picture quality means high resolution throughout the whole picture (including the edges), lifelike colors, high frame rate, fast and precise auto focus, smooth zooming, an overall distortion free picture, even lighting without reflections or hot spots and much more Minimum performance specifications shall be as follows:

- Camera Image pick-up device 1/3" CMOS, 1,350,000 pixels
- Effective SXGA output 1280 (H) x 1024 (V)
- Pixels HD 720p output 1280 (H) x 720 (V)
- XGA output 1280 (H) x 960 (V)
- Frame rate 30 frames/sec.
- Resolution RGB output 800 (H) x 800 (V) TV lines
- Video output 450 (H) TV lines
- Optics Zoom Powered, 16x optical
- Lens F2.7, f=4.9 to 78.4 mm
- Shooting area SXGA Max. 405 x 324 mm, min. 30 x 24 mm
- HDTV Max. 405 x 224 mm, min. 30 x 17 mm
- XGA Max. 405 x 303 mm, min. 30 x 23 mm
- Focus Auto/Manual (powered)
- Functions White balance Full-Auto/One-Push/Manual

- Negative/positive conversion provided
- Image mode Text 1, Text 2, Text 3, Graphics
- Edge enhancement provided (in Graphics mode)
- Color/B&W selection
- Pause mode
- Digital zoom provided (4x)
- Gamma adjustment provided (in Graphics mode)
- OSD (on-screen display) provided
- Slide show Provided (SD card image)
- Split screen Provided (SD card image, 9-split, 16-split)
- Image save provided (onto SD card)
- Image rotation Provided (0°, 180° for forward shooting)
- State presetting Up to 8 user settings
- Annotation provided (on PC screen)
- Screen separation provided (on PC screen; live image + saved image)
- Sync. System Internal
- Interface internal selection Int. /RGB
- Analogue RGB output SXGA (1280 x 1024 @60Hz)
- HD 720p (1280 x 720 @60Hz)
- XGA (1024 x 768 @60Hz)
- Video output Composite (x1), S-Video (x1)
- DVI output provided (x1)
- RGB input provided (x1)
- RS-232C port provided (x1)
- USB port provided (x1)
- Memory card SD card slot provided (x1)
- Lighting Upper lighting unit provided (white LED)
- Others Accessories AC adapter, Power cord (1.5 m), Video RCA cable (3 m),
- RGB cable (2 m), DVI cable (2 m), S-Video cable (2 m),
- USB cable (1.8 m), Instruction manual, IR remote control,
- Slide shooting adapter, Remote control case,

- Utility software (Image Mate) CD-ROM
- Dimensions set up 376 x 482 x 549 mm
- Built-in 3.5" LCD monitor Provided
- TWAIN driver

LCD DISPLAYS

- LCD Panel: Active Matrix TFT
- Resolution: 1920 x 1080
- Brightness: 700 cd/m²
- Viewing angle: 178° horizontal and vertical
- Inputs: Composite Video 1 line (BNC x2),
- RGB input: Analogue RGB: 1 line (D-sub-15-pin)
- DVI Input: DVDI x1 line
- Features: Ultra thin front bezel for tiled mounting: (15mm width for 42”and 17mm width for 52”)
- Special 10 Bit LCD Panel
- Adjustable gain and cut off for color color calibration
- Full metall chassis for 24/7 operations
- RS232/485 and LAN control functions

Approved Manufacturers for LCD Displays

1. SHARP
2. SAMSUGN
3. SONY
4. PANASONIC
5. Or approved Equal

INSTALLATION HARDWARE

All connection panels/facility panels in floor, wall or lectern shall be from approved manufacturers. Locally made panels will not be accepted. Racks used shall be of industrial grade from manufacturers.

All ceiling and wall mounts shall be from the manufacturer of the installed product or from Chief or approved equivalent. The approved manufacturer's names are to be strictly complied with to maintain the quality of the installation.

LECTURE / SYMPOSIUM

The Interactivity on the LCD shall be achieved with a specially developed Optical Sensing technology, maintaining bright high contrast picture quality, accuracy and sensitivity ideally suited for educational whiteboard applications with the following minimum performance

Specifications:

- Diagonal size 17.0 inch
- Display type Flat Panel Display / TFT active matrix-desktop / fluorescent backlight
- Resolution 1024 x 768
- Pitch 0.297 mm
- Color support 16.7 M (8 bits color)
- Brightness 200 cd /m² (typical)
- Contrast ratio 300 : 1
- Video input HD15 Analog
- Video output HD15 Analog
- Display screen Anti-Scratch Protective Glasses
- Operating systems Windows 98, 2000, ME, XP, and Tablet XP compatible
- Technology Electromagnetic
- Interface USB Port

EXECUTION

- Submit manufacturer's product data sheets for all materials and equipment proposed for use on the project.
- Mark each product data sheet to show applicable choices and options. Where product data includes information on several products, some of which are not required, mark to indicate the applicable information.

- For each manufactured device submit manufacturers' specifications and print photograph of proposed products. Include engineering descriptions, installation instructions, operation application, and proposed model, style or size clearly indicated.

42.8 QUALITY ASSURANCE

The Contractor shall submit Certification of successfully completing a Factory Certification and evidence that is completed at least five (5) projects of similar design and is currently engaged in the installation and maintenance of systems herein described.

42.9 WARRANTY

As per warranty specifications stated at Computer Networks clause.

42.10 SUBMITTALS

As per submittal specification stated in Computer Networks clause.

PART 4 - IPTV SYSTEM

Scope of work

The scope of work shall include design, supply, installation, configuration, testing, commissioning and maintenance and putting into operation with all required system equipment but not limited to following:

A. The IPTV shall be an IP network-based, fully distributed, digital video system. The system will utilize Local Area Networks as a transmission medium for TV Satellite Channels as well as video contents. The system shall provide full video control at the monitoring room, with additional full selection capability at any point within the network from TV Set connected Via STB.

B. The IPTV System shall promote a rapid rollout of new TV & Video across the whole organization. It shall utilize the existing network infrastructure without needing extra Cable or Dishes or adding extra TV system.

C. The IPTV System shall encoding Video into a format transmittable over the IP network. The encoding devices shall produce a single channel on the network.

Encoded video sources shall include encrypted TV channels from a set-top box.

D. <u>Particular Specifications</u>:

A. The IPTV encoders shall support MPEG2 H.264 SD audio & video encoding and multiplexing device with powerful functionality. It shall have 4 independent channels of unbalanced audio & video input interfaces, supporting MPEG2 and H.264 encoder type. Furthermore, it can support the MPEG-1 Audio layer 2, LC-ACC, HE-AAC and each channel can support ultra low bit rate. Also have an ASI input and can multiplex the input TS with the 4 encoded SPTS to generate a MPTS output and users can select the MPTS and 4SPTS through the front panel operation.

B. The IPTV Head End Gateways shall support DVB-S & DVB-S(2) that shall provide access to satellite channels. This TV gateway shall be capable of receiving the multiplex of TV channels, splitting the multiplex into its individual corresponding channels and then making them available on the network. The TV gateway shall capable of streaming SD DVB-S and HD DVB-S(2) television channels

C. The IPTV Head End gateways shall pass through all broadcast information relating to the channels in the multiplex, including language variations, subtitling and Electronic Program Guide information

D. The IPTV Head End gateway shall include a built-in conditional access module (CAM) to allow the descrambling of encrypted/restricted television channels..

E. The IPTV system shall have a comprehensive graphical user interface (GUI). This interface shall be provided from a central server on the network. The GUI shall provide end-users with simple navigation for viewing channels available from the network.

F. The IPTV System GUI Interface shall be Channels accessible from the portal could be from multiple sources (live TV, encoded video) but the portal shall represent them to the end-user as a continuous list of available channels, regardless of the source. The portal shall work with both SD and HD STBs

G. The IPTV System GUI Interface shall provide access to satellite radio (audio only) channels that end-user is currently allowed to access from the network.

H. The IPTV Receivers or Set-Top-Box's shall be high Definition (HD) & act as an intermediary between the IP network infrastructure and the final viewing device (LCD, Plasma, digital projector etc). The HD STBs shall capable of supporting H.264 shall capable of supporting both HD and SD TV and video signals video decoding. HD STB shall have a HDMI connection.

I. The IPTV System shall have efficient management Tool. Administration shall be via a standard PC application with the ability to bulk configure multiple devices (for speed of set-up and upgrade) and perform individual device configuration (for precision set-up and customization of the IPTV network).

J. The IPTV management system shall have the ability for configuration and control using the device's IP address on the network. This shall provide the administrator with a web-based interface where specific configuration shall be set.

K. The IPTV System components hardware shall have an admin port, allowing installers and administrators the ability to connect directly to the device, improving the speed of installation and error correction.

L. All components used shall be from single vendor for the best quality and services and for easy maintenance of the system.

Products:

The IPTV System components shall be & not limited to the following:

1. IPTV Head End that creates streaming TV and video channels from satellite TV broadcast sources and in-house video sources.
2. IP TV Head End shall support (from day one) 40 Channels FTA from 6 different DVB-S/S2
3. Set-top-boxes that decode TV from network to output on attached displays.
4. Management system to support configuration, monitoring and maintenance of the system

IPTV Head End:

1. The IPTV Head End system shall be modular to allow flexible scalability to support present needs and any future upgrade without the need to replace any of the system components
2. All Head End Hardware & Servers shall be 19" rack mountable types.
3. Digital satellite signals shall be captured via at least 4 ft. dish antennas
4. Digital channels remain to be MPEG2 or MPEG4 format at all stages of the system and shall not be converted, modulated or transformed in to analogue RF signal.
5. The IP TV Head End System shall have an open structure permitting the support of any iTV services for future use, if needed.

Satellite Dishes:

Dish Antennas shall be constructed of light galvanized steel with positive locking of all elements in position. All mounting and fixing materials shall be protected against corrosion by heavy anodic coating or corrosion resisting compound. The dish antennas shall be fixed to a mast mounted on the roof of the building. Masts shall be heavy-duty hot dipped galvanized steel securely fixed to the roof so as to ensure resistance to the strongest winds encountered in the locality.

Dish antennas shall comprise of the following minimum specification:

1) 1.05M Solid w/ Azel Mount:

Dish Diameter:	105 cm
Focal Length:	58.3
F/D Ratio:	0.63
Frequency Range:	10 ~ 12.75 GHz
Gain at 11.7 GHz:	39.2 dB
Efficiency:	> 60%
Reflector Material:	Electro Zinc-Coated Steel
Finish:	Polyester Coating
Type of Fixing:	Wall/Pole

Wind Speed:	Operating: Up to 100 km/h, Maximum: Up to 130 km/h

2) 1.2M Fixed C/Ku solid Antenna:

Dish Diameter:	120cm
Focal Length:	33 (68.2cm)
F/D Ratio:	0.37
Frequency Range:	1.0 ~ 12.75 GHz
Gain at 4.2 GHz:	36 dB
Gain at 12.2 GHz:	44.9 dB
Efficiency:	0%
Reflector Material:	Galvanized Steel
Finish:	Electrostatic Power Coating
Feed:	Prime Focus
Mount:	Polar
Max Wind Speed:	150 Km (Operational)

3) LNBF Converters

Band:	Ku
No. of Inputs:	4
Polarity:	V-Hi, V-Lo, H-Hi, H-Lo
Freq.Range:	Low band:10.7~11.7 GHz
High band:	11.7~12.75 GHz
Noise Fig at 20Deg:	C: 0.9
Input VSWR:	2.5:1
Input RF level:	-100 to -55 dBm
Image Rej Ratio:	45dB
Output Frequency:	Low band:950-1450 MHz
High band:	1100-2150 MHz
Power Gain:	56~65 dB

Output Impedance: 75 ohms

Operating Temp: -40Deg.C to

IPTV Gateway:

1) The IPTV head-end unit shall be a modular based system
2) The IPTV head-end unit shall receive transport streams from a variety of input sources including ASI, QPSK, IP, COFDM or QAM, descramble and re-scramble selected services, before streaming via IP or ASI. For monitoring of services, the IPTV head-end can be equipped with decoder cards.
3) The IPTV head-end supports full analysis of PSI/SI and regenerates all tables as required.
4) The IPTV head-end shall has a built in interface software that allows clients to login and easily select which TV program to view. Channel updates shall be instantly displayed to the client interface and shall not require a head-end restart to update the channel list.

The satellite IPTV head-end unit consists of the following modules and with the following parameters and technical specifications:

Chassis: The main features of the chassis are:

- 19” rack ready, 4RU
- Modular configuration with up to 7 positions for cards
- Web-based system configuration
- Forced air-cooling
- Any combination of inputs, processing and output modules.
- Single Power Supply input voltage: 115-230 Vac, 50/60Hz
- Redundant Power Supply (optional) input voltage: 90-264 Vac, 50/60Hz
- IPMI (Intelligent Platform Management Interface) for out-of-band management.

DVB-S/S2 Inputs:

- Dual or Single DVB-S/S2 Input
- Input frequency range: 950 - 2150 Mhz
- Input level: -69~-23dBm
- Modulation: 8PSK, QPSK
- Symbol rate range: 1~45Msps
- Carrier Capture Range: ±10MHz
- FEC Rate:
- 8PSK: 3/5,2/3,3/4,5/6,8/9,9/10
- QPSK: 1/2,3/5,2/3,3/4,4/5,5/6,8/9,9/10
- Support Data Burst & Tone Burst
- Support DiSEqC2.X
- F female connector
- Supports reception for SPTS and MPTS
- Service and PID filtering

DVB-S/S2 Input W/CI :

- Dual DVB-S/S2 Input
- Input frequency range: 950 - 2150 Mhz
- Input level: -69~-23dBm
- Modulation: 8PSK, QPSK
- Symbol rate range: 1~45Msps
- Carrier Capture Range: ±10MHz
- FEC Rate:
- 8PSK: 3/5,2/3,3/4,5/6,8/9,9/10
- QPSK: 1/2,3/5,2/3,3/4,4/5,5/6,8/9,9/10
- Support Data Burst & Tone Burst
- Support DiSEqC2.X
- Dual CI Slot
- F female connector

- Supports reception for SPTS and MPTS
- Service and PID filtering

Ethernet Output module:

- 2x 10/100/1000BaseT (RJ45) (Management + Streaming)
- Support for UDP/RTP Multicast/Unicast Ipv4/IPv6 transmission
- Support for SPTS
- Data rate streaming up to 500 Mbit/s
- Transport stream, MPEG-2 SD/HD, MPEG-4 SD/HD, AAC, DD+ ...
- PIDs filtering
- EPG Pass-through of EIT, SDT and TDT tables
- SAP announcements
- Embedded Web Server

Environmental Specifications

1) Operating Conditions:

- Operational Temperature: 0°C to +40°C
- Operational Humidity: 0% to 95% (non-condensing)
- Storage Temperature: -20ºC to +70 ºC
- Storage Humidity: 5% to 95% (non-condensing)

2) Ventilation:

- Cooling: Integrated fans (airflow front to back)
- Number of fans: 4
- Control Interface: diodes on chassis. Hot-swappable, mounted on opposite side of Input/output modules.

3) Physical Dimensions:

- Dimensions: 19” x 4RU

Technical Parameters

- System : Linux
- Network: 10/100/1000 Base-T Ethernet interface
- Output format: MPEG Transport Stream (TS) over UDP
- Output bandwidth: up to 800mbps ~5 Mbit/s per channel
- Networking protocols: Unicast & multicast with IGMP protocol
- Format: any DVB transport stream
- Modulation: QPSK

Technical Specifications

- LNB F type input: Composite RCA and SVIDEO input
- C & Ku band support Formats: PAL/SECAM
- RF input level: -65 to -25 dBm MPEG2 format:720x576
  25 pictures/sec; 24 bits
- Input frequency: 950 to 2150 MHz
- Symbol rate: 1 to 45 MSyb/s, SCPC and MCPC support
- Supports: LNB 14/18V / OFF max 400 mA; 22 KHz,
- Band switch control: (DiSEqC 1.0)
- Size: 4U Rack
- Alimentation: 125W 22V/110V

Decryption:

Decryption methods for Conax, Irdeto, Cryptoworks, Nagra, NDS, Viaaccess protocols

Software

The IPTV head-end unit shall provides a web interface software for management of the installed modules. A web interface for viewing of the selected TV programs shall be available on the IPTV head-end.

The IPTV head-end shall be a hardware-based processing system, and utilizes LINUX platforms only for purposes of basic management tasks, including web-based user interface. Hardware-based processing systems ensures for maximum uptime, unlike software based processing systems.

32.3.4 IP Set Top-Box:

The IP TV Set-Top-Box (STB) shall support Video compression in Mpeg 2/4 format High Definition (HD) resolution. The STB Shall have the following specifications:

- MPEG2 and MPEG4 AVC / H264 platform.
- High definition resolution up to 1080p60.
- Advanced user interface navigation via embedded browser.
- HDMI interface with HDCP copy protection.
- Dual USB 2.0 high-speed communication port.
- TV Interactive interface (TVI) and IR extender.
- Remote configuration and management.
- Open-standards based software stack.
- Modular software architecture ready for features and services development.
- H TML5 web-browser with extended JavaScript API.
- Eco-designed STB with very low power consumption (~3W).

SYSTEM	Multicore Processor
	Host CPU MIPS@700MHz
	Secure CPU MIPS@350MHz
	512MB DDR2 memory
	512 MB Nand flash memory
	Dual HD video decoder
	JPEG hardware acceleration
	2D graphics acceleration
	32-bits OSD

Data Protocols	HTTP 1.1
	HTTPS
	HTML5.0 (321/500 points +2 bonus in html5test)
	XHTML 1.1
	Dynamic HTML
	CSS3, CSS2
	DOM 1.0 & 2.0
	XML 1.1
	JavaScript 1.8 & AJAX
	JSON
	XMLHttpRequest
A/V Protocols	IPTV Multicast (IGMP v2/v3)
	Video over UDP, RTSP and HTTP
	HLS (HTTP Live Streaming)
	HTML5 audio and video tags
	Frames & i-Frames support

VIDEO CAPABILITIES

Decoding:	MPEG1
	MPEG2 MP@HL
	MPEG-4.2 ASP@L5
	(up to HD resolution, 1-point GMC)
	MPEG-4.10 (H.264) MP@L4.0 and HP@L4.0
	H.261

AUDIO CAPABILITIES

Decoding:	Dolby Digital 5.1, Dolby Digital Plus 5.1
	MPEG-1 Layers I, II and III (MP3) 2.0
	MPEG-4 AAC-LC 5.1
	MPEG-4 HE-AAC 5.1
	FLAC

OGG vorbis

ADPCM DVI

G.711 (A-law and μ-law)

PICTURE CAPABILITIES

Decoding: JPEG (SW decoded or HW accelerated decoding)

1x1 to 2048x2048 resolution

YCbCr and RGB (4:4:4 only)

4:4:4, 4:2:2 and 4:2:0

Baseline and progressive

PNG/MNG (SW decoded)

GIF (SW decoded)

BMP (SW decoded)

FONT/CLOSED CAPTIONS

OpenType Fonts

TrueType Fonts

Postscript Fonts

Render EIA-608 closed captions in software

Render EIA-708 closed captions in software

SUPPORTED FORMATS

Audio

MPEG-1 Audio Layer 3 (MP3)

MPEG-1 Audio Layer 2 (MP2)

AAC, HE-AAC, ATRAC3, FLAC, OGG Vorbis &

AC3

MPEG-1 System

MPEG2 Program (M2P), MPEG-2 Transport

(M2T) (188- and 192-bit packets)

MPEG-4.14 (MP4)

Matroska Multimedia Format (MKV)

	Audio Video Interface (AVI)
	Flash Video (FLV)
	Resource Interchange File Format (RIFF)
	JPEG, SVG, BMP, GIF, TIFF & PNG
SOFTWARE STACK	Linux Kernel 2.6.29
	Qt 4.8.1 libraries
	DirectFB accelerated display driver
	ArantiaBrowser (QtWebkit based)
CONNECTIVITY	S/PDIF audio output
	Control port (TVI & IR extender)
	USB 2.0 Host connector
	Integrated HDMI v1.3a with CEC,
	RJ45 10/100/1000 Ethernet with activity&link
	LED's
GENERAL DATA	Certifications
	Low Voltage Directive 2006 / 95 / EC
	EMC Directive 2004 / 108 / EC
	Power Consumption
	Standby : < 1W
	Operating (HD decoding) : ~3W

LICENSES

Any license agreements and fees, including software, required for any equipment provided by the contractor shall be included for in the tendered price for the duration of the defects liability period.

a. The tendered shall clearly indicate any additional and on going costs related to the continuance of any such agreement.

b. Rights of use and ownership of any software provided by the contractor shall be retained by the owner.

32.5 Submittals

As per submittals specifications stated at Computer Networks clause.

32.6 Warranty

As per warranty specifications stated at Computer Networks clause.

45. ACCESS CONTROL SYSTEM

Scope of work

The scope of work shall include design, supply, installation, configuration, testing, commissioning and maintenance and putting into operation access control system for controlling and monitoring PV system and control room container with all required system equipment with smart access cards at container doors but not limited to following**:**

- Access Control System (ACS) designed for windows based operating systems with complete control to fully program, control and record all system transactions for all doors, users and operators.
- The system shall provide an operator friendly interface that is intuitive for the end user allowing system programming and operation from a single right mouse click.
- The ACS consists of a Software Package with full function workstation and all required hardware components to operate in satisfactory condition (IFNPC Intelligent Field Network Panel Controllers, Reader Controllers Module, Input/Output Controller Module and Electric locks or double door magnetic locks as per the doors. All doors will have 500 L.B magnetic locks).
- The ACS software is database based system to record all transactions and allow monitoring of all alarms on a scheduled basis locally as well as notification remotely via paging, e-mail and monitoring stations.
- Maintain total control and surveillance of all doors with access control
- Managing time of opening and closing doors.
- The system shall incorporate real time status for dynamic information of all devices and a right click for reconfiguration of any device.
- Operator levels shall have the ability to partition operators per site and function.

- The ACS has the ability to create a report of all cardholder's where-about from a "cards monitor" screen.
- The ACS shall be able to define and communicate with multiple manufacturers of digital video recorders. The interface shall allow the association of system devices to camera inputs for control and video search functions. The interface will be full function and seamless to the operator for control of cameras and searching of events.
- Live Dynamic Interactive Mapping.
- Internet Monitoring for offsite monitoring of any alarm or message notification.
- Multiple message ports notify multiple people simultaneously.
- Program any action to create any reaction
- The system shall support biometric IP-readers with the following or better specifications:
    i. 25,000 fingerprint template storage capacity
    ii. 1-to-many verification in less than 1 second (with the database of 3000 users)
    iii. 1-to-many verification with the database of 9000 users.
    iv. 500,000 event storage
    v. Built-in USB, RS-232/485, LAN and WLAN communication ports
    vi. Selectable operation modes: fingerprint, fingerprint + card, fingerprint + PIN.
    vii. Door-phone function
    viii. Microphone, speaker and 2.5" QVGA color LCD
    ix. 72MB flash memory
    x. Door contact and exit button inputs
- Lock control relay
- Access Control System (ACS) designed for windows based operating systems with complete control to fully program, control and record all system transactions for all doors, users and operators.
- The system shall provide an operator friendly interface that is intuitive for the end user allowing system programming and operation from a single right mouse click. System shall be scalable from two to unlimited doors without changing or replacing current controllers. The ACS open architecture will allow seamless interfacing to any

IP controlled device allowing the end user full building automation and operation from a single graphical user interface (GUI) or workstation.

- The ACS consists of a Software Package with a minimum three (3) full function workstations and Component hardware of Intelligent Field Network Panel Controllers, Reader Controllers Module, Input/Output Controller Module and Intelligent Keypads (IK).
- The ACS software is database based system to record all transactions and allow monitoring of all alarms on a scheduled basis locally as well as notification remotely via paging, e-mail and monitoring stations.
- The system features are :
  a) Door Management System
     - Maintain total control and surveillance of all doors with access control
     - Managing time of opening and closing doors.
     - Ability to prevent a single user card from being re-used to allow more than one person through a door access area by forcing users who enter a secure area with a card to leave the area before the card may be used to enter that secure area again.
     - Ability to prevent a single user card from being re-used to allow more than one person through a door access area in multiple doors in programmable sequences.
- The system shall incorporate real time status for dynamic information of all devices and a right click for reconfiguration of any device.
- Operator levels shall have the ability to partition operators per site and function.
- The ACS has the ability to create a report of all cardholder's where-about from a "cards monitor" screen.
- The ACS shall be able to define and communicate with multiple manufacturers of digital video recorders. The interface shall allow the association of system devices to camera inputs for control and video search functions. The interface will be full function and seamless to the operator for control of cameras and searching of events.

- Live Dynamic Interactive Mapping.
- Internet Monitoring for offsite monitoring of any alarm or message notification.
- Multiple message ports notify multiple people simultaneously.

Program any action to create any reaction

b) Time Management System

- Managing staff coming and going and have their access times logged at the smart card reader installed on a different locations in the building.
- Enables human resource personnel to monitor personnel access behavior such as promptness, tardiness, early out, overtime, absenteeism, lengthy breaks, and incomplete entries such as an out-entry but no in-entry or no outentry.

c) Visitors Management System

- Manage a large volume of visitor traffic through building's premises quickly, easily and accurately.
- Create and assign visitor cards instantly on demand.
- Keep track of visitor locations, areas visited, visitor population in a secure area, etc.
- Restrict Access to sensitive areas based on security areas, floors or even particular doors.
- Temporary cards expire automatically within a specified time so they cannot be reused later.
- Old temporary cards can be easily recycled and reassigned.
- Analysis of visitor movement can identify popular routes and visitor destinations.
- Contractor shall be fully responsible for the installation of the magnetic locks, Controllers, card readers ……etc including all and any remedial works required to the already existing facilities on site.

Access Control System Function

- The ISMS shall be windows based and operate on Microsoft SQL Server product or Oracle.
- Minimum 3 full function clients when used with MSDE.
- Minimum 10 full function clients when used with SQL server.
- The ACS shall be user friendly and intuitive to allow minimal training.
- The ACS shall incorporate real time status for dynamic information of all devices and a right click for reconfiguration of any device.
- The ACS shall use up to 999 operators with the ability to limit each operator's functions.
- Operator levels shall have the ability to partition operators per site and function.
- The ACS will run as services on the computer to provide greater reliability
- The Operator will have the ability to change views of the screen. This configuration information will be stored in the individual operator profile and be automatically recalled upon login.
- The ACS shall have the ability to customize the toolbar(s) and add icons from third party vendors so that the software acts as one.
- The ACS shall allow database segregation for multi-site installations. Operators will be segregated to manage different sites.
- The ACS shall auto logoff if system is untouched for an amount of time set by operator.
- The ACS current events screen will be interactive and allow right-click access to reconfigure any allowed device or cardholder and have pause, freeze and clear functions as well as sort by column features all configured by right clicking.
- Schedules within the ACS shall be common to all devices for simplicity in programming.
- The ACS shall have the ability to create holidays to assign to the system.
- The ACS shall have the ability to create access levels to assign to cardholders and to assign special access per door resulting in a custom access level for each cardholder in the system.

- The access levels within the ACS shall have elevator assignments for easy operator access.
- The ACS shall have the ability to create companies within the software for operator partitioning.
- The ACS has the ability to create a report of all cardholder's where-about from a "cards monitor" screen.
- The ACS shall incorporate "dynamic ASCII messages" to interact with other systems in a real time mode for integration with Integrated building Management System
- The ACS shall have the ability to group devices for single command operations.
- The ACS shall have the ability to assign multiple facility codes and assignable to different readers within the system for card partitioning.
- The ACS shall be able to define and communicate with multiple manufacturers of digital video recorders. The interface shall allow the association of system devices to camera inputs for control and video search functions. The interface will be full function and seamless to the operator for control of cameras and searching of events.
- The ACS shall incorporate "real time dynamic mapping". Map creation software must be incorporated within the system and mapping module of IP CCTV. A map import tool for external drawings must also be included. Device icons shall be drag and drop onto the map and interactive for the end user. Virtual icons shall be available for non-system devices such as cameras.
- The ACS shall incorporate an alarm screen that has a two stage acknowledgement system. Stage 1 the operator acknowledges the alarm and stage 2 is action operator action is recorded and logged to clear alarm.
- The ACS shall incorporate a full log of all system programming and events. This information shall be accessible at any time by using the reporting functions. Within the reports section shall be pre-defined reports for easy operator access. The reports shall be searchable and exportable to different document formats.

- The ACS shall incorporate a full badge creation program (integration to third party badging is not acceptable). The user shall be able to create and design multiple badges and assign fields at will within the system for full graphic layouts.
- The ACS shall be able to print to any widows driven card printer.
- The ACS shall have a back-up scheduler for automatic back-ups and the ability to run back-ups manually.
- The cardholder record shall have activation and deactivation dates
- The cardholder record shall have normal access level assignments and special access level assignments.
- The cardholder record shall allow “lock/unlock”,” high security”, “ignore functions” and stealth mode on an individual basis.
- The ACS shall incorporate an expandable tree system for adding system devices. Devices can be added by right clicking on the expandable tree.

ACS Special Features

- High Security mode for readers. Initiated by Card, Schedule, Link or Operator
- Four swipe mode for cardholder to initiate high security mode
- Double swipe mode for cardholder to Lock/Unlock Access Points without the intervention of computer.
- IP CCTV integration to multiple manufacturers of IP CCTV at the same time.
- Live Dynamic Interactive Mapping.
- Internet Monitoring for offsite monitoring of any alarm or message notification.
- Dynamic messages for exact message notification.
- Multiple message ports notify multiple people simultaneously.
- Message management by time schedules
- Program any action to create any reaction
- Reads all common weigand formats. Up to 5 simultaneously on a single port
- Reads multiple card technologies simultaneously (smartcard, biometrics)

Intelligent Field Network Panel Controllers (IFNPC).

Physical Characteristics:

- 9-14 VDC operation
- 32 bit Motorola Microcontroller
- 256k memory expandable to 16Mb
- 0-70 degrees operating temperature
- 20-80% Relative Humidity (non-condensing)
- Built in watchdog circuit with LED indications
- Built in clock
- Status LED's for all communication ports
- Fail Over Connectivity to the Reader Controller Module & Input/Output Controller Module:

Reader Controller Module Characteristics:

- Two Reader Ports (weigand/ magstripe)
- 8 inputs fully supervised
- 8 outputs (4 form C relays, 4 electronic drivers)
- All outputs fused

Input/Output Controller Module Characteristics:

- 16 Inputs /outputs field configurable
- All power outputs fused

Operating Characteristics:

- The IFNPC shall be a 32 bit microprocessor capable of performing all functions of its network and related devices without the use of the computer. This shall be deemed as intelligent.
- The IFNPC shall hold all data pertinent for allowing/denying or operating any field device attached to its Network without the use of the computer.
- The IFNPC shall be dip switch configurable to be a master or slave on any given network without changing or adding firmware or memory.

- The IFNPC shall be capable of communicating to the computer via RS232, RS485, and TCP/IP Ethernet.
- The IFNPC shall employ the use of "Flashware" for future upgrades and upgradeable by the system computer without the need for local intervention.
- The IFNPC shall employ the use of LED's to indicate all status of communication for the IFNPC and for diagnostics and running status
- The IFNPC shall buffer a minimum of 10,000 events in the event of computer failure (expandable to 500,000).
- The IFNPC shall incorporate static RAM so that all functions return to normal when power is reapplied after prolonged power failure

Reader Controller Module (RCM)

- The RCM shall be capable of supporting up to five (5) different reader formats simultaneously.
- The RCM shall read all available weigand and smartcard formats.
- The RCM shall incorporate a charging circuit with deep discharge protection for standby battery protection.
- The RCM shall have plug in connectors for easy installation.
- The RCM shall support single or double line led reader technologies.
- The RCM shall have a separate power supply built in for additional power requirements.
- The RCM shall support two readers per unit
- All inputs or outputs shall have Led annunciation
- The RCM shall have built in fingerprint readers for alternative/extra control.

Locks:

Electric locks or double door magnetic locks as per the doors. All doors will have 500 L.B magnetic locks. Lock to operate by 12 or 24 Volts DC and shall have battery backup.

Request to Exit Button:

Request to exit button (Egress button) shall be supplied where ever shown on drawings for EXIT application. The button must have engraved “EXIT” and must be connected to appropriate controller.

INTERFACE PANELS

The selection of Interface Panels shall include at least Door/Reader Interface Panel, Input Monitor Interface Panel and Output Control Interface Panel.

- The Interface Panels shall connect with Network Controllers using RS-485 bus. Door/Reader Interface Panels shall have two reader interfaces utilizing standard Wiegand protocol. Depending on application, the panel can be configured to control two sets of separate doors with a reader and an exit button, or one door with two-side readers (entry/exit).
- In addition to the two reader interfaces, the Door/Reader Interface Panels shall have the following inputs and outputs: door monitor input, exit button input, strike relay output, auxiliary relay output.Door/Reader Interface Panels shall be capable of indicating door forced and door held alarms also locally by using the internal beeper of the reader. Interface Panels shall have local inputs for tamper and battery failure for indications and alarms.
- The Input Monitoring Interface Panel shall be used to interface e.g. magnetic contacts to indicate alarm events. The Input Monitoring Interface Panel shall include 16 supervised alarm inputs and 2 relay outputs.
- Output Control Interface Panel shall be used mainly to control lifts. The Output Control Interface Panel shall have 12 relay outputs and 2 supervised alarm inputs.
- It shall be possible to create complex I/O linking and rules between Network Controllers and Interface Panels.

VIDEO MONITORING

- Video monitoring shall be implemented with IP CCTV system. The video monitoring system shall be integrated to IBMS server so that the system shall start recording video stream upon triggering from access control, CCTV or any other system integrated to IBMS.
- The video monitoring system shall support IP cameras. Usage can be done both via video monitoring system's own User Interface and the integrated user interface of the IBMS.

APPROVED MANUFACTURERS

List of approved Manufacturers for IP ACS:

- CARDEX
- RBH
- HID
- ACTATECK
- Axis
- BOSCH
- Or equally approved manufacturer by project engineer(s).

WARRANTY

As per warranty specifications stated at Computer Networks clause.

SUBMITTALS

As per submittals specifications stated at Computer Networks clause.

NETWORK DISTRIBUTION

Any IP transmission shall be of CAT 6A with matching RJ-45 crimp type connectors, and shall be installed with a control crimp tool, specified by the connectors' manufacturer.

TESTING AND COMMISSIONING

The completed installation shall be tested and commissioned with a representative of the Client in attendance. The manufacturer representative shall also instruct and train the security staff in the operation of the system and supervise the security staff operating the system for a minimum period of ten hours over two consecutive days.

WIRELESS NETWORKING SYSTEM

Scope of work

Unified access points operate with the Lightweight Access Point Protocol (LWAPP) and work in conjunction with the wireless LAN controllers and the Wireless Control System (WCS). Autonomous access points are based on Software.
Wireless LAN Solution Engine (WLSE). Autonomous access points, along with the WLSE, deliver a core set of features and may be field-upgraded to take advantage of the full benefits of the Wireless Network as requirements evolve.

Wireless Access points

The Wireless Access Points must be manufactured by the same vendor providing edge Switches, Access Switches, Unified Communication Components, Wireless LAN Components, Security Components and the Network Management components for feature transparency and compatibility and to guarantee optimum performance.

- Must have Dual 802.11a and 802.11g Radios.
- Must have Dual RP-TNC Antenna Connectors for Both 2.4-GHz and 5-GHz Radios
- Must be configured with 1 x 2.4 GHz, 6 dBi Patch Antenna w/RP-TNC Connector
- Must support Link-Role Flexibility
- Must support Management Frame Protection
- Must support the following security features:
    - Security Standards
    - WPA, WPA2 (802.11i)
    - TKIP, message integrity check (MIC), IEEE 802.11 WEP keys of 40 bits and 128 bits
    - EAP-Flexible Authentication via Secure Tunneling (EAP-FAST)
    - Protected EAP-Generic Token Card (PEAP-GTC)
    - PEAP-Microsoft Challenge Authentication Protocol Version 2 (PEAPMSCHAP)
    - EAP-Transport Layer Security (EAP-TLS)
    - EAP-Tunneled TLS (EAP-TTLS)
    - EAP-Subscriber Identity Module (EAP-SIM)
    - LEAP
    - AES-CCMP encryption (WPA2)

  - TKIP (WPA)
  - WPA TKIP
  - IEEE 802.11 WEP keys of 40 bits and 128 bits
- Must support 12 Non-Overlapping Channels, with potentially up to 23 Channels
- Must support Rugged Metal Housing
- Must support UL 2043 Plenum Rating and Extended Operating Temperature
- Must support Multipurpose and Lockable Mounting Bracket
- Must support Local and Inline Power Supported, Including IEEE 802.1af PoE and Power Injector.
- Must have Hardware-Assisted AES Encryption
- Should support network discovery protocols such as CDP.
- Should support remote centralized and automatic upgrade of firmware for ease of manageability
- Must Support the following data rates:
  - 802.11a: 6, 9, 12, 18, 24, 36, 48, and 54 Mbps
  - 802.11g: 1, 2, 5.5, 6, 9, 11, 12, 18, 24, 36, 48, and 54 Mbps
- Must have Autosensing 802.3 10/100BASE-T Ethernet
- Must be configured with 16MB flash memory
- Must be configured with 32MB RAM.
- Should be able to act as a local authentication server to IEEE 802.1x wireless clients when the authentication server is not available.
- Should support a minimum operating temperature range of -20 to 55ºC.
- Should support all of the following transmit power settings: 1mW, 2mW, 3mW, 6mW, 12mW, 25mW, 50mW, and 100mW.
- Should support the autonomous and the thin Lightweight Access Point Protocol (LWAPP) deployment modes for investment protection.
- Must have Status, Ethernet and Radio LED's
- Must have Wi-Fi Certification
- Must Comply with the following standard:
  - Safety:
    - UL 60950-1
    - CAN/CSA-C22.2 No. 60950-1
    - UL 2043
    - IEC 60950-1
    - EN 60950-1
    - FIPS 140-2 Pre-Validation List
    - Common Criteria (IOS Software only)
  - Security:
    - 802.11i, WPA2, WPA
    - 802.1X
    - AES, TKIP
  - Other:
    - IEEE 802.11g and IEEE 802.11a
    - FCC Bulletin OET-65C
    - RSS-102

Wireless LAN Controller

- The Wireless LAN Controller must be manufactured by the same vendor providing Core Switches, Access Switches, Unified Communication Components, Wireless LAN Components, Security Components and the Network Management components for feature transparency and compatibility and to guarantee optimum performance.
- Must support a minimum of 50 access points.
- Must have a minimum of two Gigabit Ethernet ports.
- Must be configured with 2 x 1000BASE-T SFP.
- Must be delivered with redundant AC Power Supply.
- Must support IEEE 802.11a, 802.11b, 802.11g, 802.11d, 802.11h
- Must support IEEE 802.3 10BASE-T, IEEE 802.3u 100BASE-TX specification
- Must support IEEE 802.1Q VLAN tagging, and IEEE 802.1D Spanning Tree Protocol
- Must support the following RFC:
    - RFC 768 UDP
    - RFC 791 IP
    - RFC 792 ICMP
    - RFC 793 TCP
    - RFC 826 ARP
    - RFC 1122 Requirements for Internet Hosts
    - RFC 1519 CIDR
    - RFC 1542 BOOTP
    - RFC 2131 DHCP
- Must support the following security standards:
    - WPA
    - EEE 802.11i (WPA2, RSN)
    - RFC 1321 MD5 Message-Digest Algorithm
    - RFC 1851 The ESP Triple DES Transform
    - RFC 2104 HMAC: Keyed Hashing for Message Authentication
    - RFC 2246 TLS Protocol Version 1.0
    - RFC 2401 Security Architecture for the Internet Protocol
    - RFC 2403 HMAC-MD5-96 within ESP and AH
    - RFC 2404 HMAC-SHA-1-96 within ESP and AH
    - RFC 2405 ESP DES-CBC Cipher Algorithm with Explicit IV
    - RFC 2406 IPsec
    - RFC 2407 Interpretation for ISAKMP
    - RFC 2408 ISAKMP
    - RFC 2409 IKE
    - RFC 2451 ESP CBC-Mode Cipher Algorithms
    - RFC 3280 Internet X.509 PKI Certificate and CRL Profile
    - RFC 3602 The AES-CBC Cipher Algorithm and Its Use with IPsec
    - RFC 3686 Using AES Counter Mode with IPsec ESP

- Must support the following Encryption:
  - WEP and TKIP-MIC: RC4 40, 104 and 128 bits (both static and shared keys)
  - SSL and TLS: RC4 128-bit and RSA 1024- and 2048-bit
  - AES: CCM, CCMP
  - IPSec: DES-CBC, 3DES, AES-CBC
- Must support the following Authentication, Authorization, and Accounting (AAA):
  - IEEE 802.1X
  - RFC 2548 Microsoft Vendor-Specific RADIUS Attributes
  - RFC 2716 PPP EAP-TLS
  - RFC 2865 RADIUS Authentication
  - RFC 2866 RADIUS Accounting
  - RFC 2867 RADIUS Tunnel Accounting
  - RFC 2869 RADIUS Extensions
  - RFC 3576 Dynamic Authorization Extensions to RADIUS
  - RFC 3579 RADIUS Support for EAP
  - RFC 3580 IEEE 802.1X RADIUS Guidelines
  - RFC 3748 Extensible Authentication Protocol
  - Web-based authentication
- Must support the following Management:
  - SNMP v1, v2c, v3
  - RFC 854 Telnet
  - RFC 1155 Management Information for TCP/IP-Based Internets
  - RFC 1156 MIB
  - RFC 1157 SNMP
  - RFC 1213 SNMP MIB II
  - RFC 1350 TFTP
  - RFC 1643 Ethernet MIB
  - RFC 2030 SNTP
  - RFC 2616 HTTP
  - RFC 2665 Ethernet-Like Interface types MIB
  - RFC 2674 Definitions of Managed Objects for Bridges with Traffic Classes, Multicast Filtering, and Virtual LAN Extensions
  - RFC 2819 RMON MIB
  - RFC 2863 Interfaces Group MIB
  - RFC 3164 Syslog
  - RFC 3414 User-Based Security Model (USM) for SNMPv3
  - RFC 3418 MIB for SNMP
  - RFC 3636 Definitions of Managed Objects for IEEE 802.3 MAUs
  - MIBs
- Must support the following Management Interfaces:
  - Web-based: HTTP/HTTPS
  - Command-line interface: Telnet, SSH, serial port
- Must have the following interfaces and indicators:
  - Uplink: 2 x 1000Base-X transceiver slots

- LED indicators: link, activity
- Service Port: 10/100 Mbps Ethernet (RJ45)
- LED indicators: link, activity
- Utility Port: 10/100/1000 Mbps Ethernet (RJ45)
- LED indicators: link, activity
- Expansion Slots: 1
- Console Port: RS232 (DB-9 male, DTE interface)
- Other Indicators: Status, Alarm, Power Supply 1, Power Supply 2

DMZ Wireless LAN Controller

The Wireless LAN Controller must be manufactured by the same vendor providing Edge Switches, Access Switches, Unified Communication Components, Wireless LAN Components, Security Components and the Network Management components for feature transparency and compatibility and to guarantee optimum performance.

- Must support a minimum of 12 access points.
- Must have a minimum of two Gigabit Ethernet ports.
- Must be configured with 2 x 1000BASE-T SFP.
- Must support redundant AC Power Supply.
- Must support IEEE 802.11a, 802.11b, 802.11g, 802.11d, 802.11h
- Must support IEEE 802.3 10BASE-T, IEEE 802.3u 100BASE-TX specification
- Must support IEEE 802.1Q VLAN tagging, and IEEE 802.1D Spanning Tree Protocol
- Must support the following RFC:
  - RFC 768 UDP
  - RFC 791 IP
  - RFC 792 ICMP
  - RFC 793 TCP
  - RFC 826 ARP
  - RFC 1122 Requirements for Internet Hosts
  - RFC 1519 CIDR
  - RFC 1542 BOOTP
  - RFC 2131 DHCP
- Must support the following security standards:
  - WPA
  - EEE 802.11i (WPA2, RSN)
  - RFC 1321 MD5 Message-Digest Algorithm
  - RFC 1851 The ESP Triple DES Transform
  - RFC 2104 HMAC: Keyed Hashing for Message Authentication
  - RFC 2246 TLS Protocol Version 1.0
  - RFC 2401 Security Architecture for the Internet Protocol
  - RFC 2403 HMAC-MD5-96 within ESP and AH
  - RFC 2404 HMAC-SHA-1-96 within ESP and AH
  - RFC 2405 ESP DES-CBC Cipher Algorithm with Explicit IV
  - RFC 2406 IPsec

  - RFC 2407 Interpretation for ISAKMP
  - RFC 2408 ISAKMP
  - RFC 2409 IKE
  - RFC 2451 ESP CBC-Mode Cipher Algorithms
  - RFC 3280 Internet X.509 PKI Certificate and CRL Profile
  - RFC 3602 The AES-CBC Cipher Algorithm and Its Use with IPsec
  - RFC 3686 Using AES Counter Mode with IPsec ESP
- Must support the following Encryption:
  - WEP and TKIP-MIC: RC4 40, 104 and 128 bits (both static and shared keys)
  - SSL and TLS: RC4 128-bit and RSA 1024- and 2048-bit
  - AES: CCM, CCMP
  - IPSec: DES-CBC, 3DES, AES-CBC
- Must support the following Authentication, Authorization, and Accounting (AAA):
  - IEEE 802.1X
  - RFC 2548 Microsoft Vendor-Specific RADIUS Attributes
  - RFC 2716 PPP EAP-TLS
  - RFC 2865 RADIUS Authentication
  - RFC 2866 RADIUS Accounting
  - RFC 2867 RADIUS Tunnel Accounting
  - RFC 2869 RADIUS Extensions
  - RFC 3576 Dynamic Authorization Extensions to RADIUS
  - RFC 3579 RADIUS Support for EAP
  - RFC 3580 IEEE 802.1X RADIUS Guidelines
  - RFC 3748 Extensible Authentication Protocol
  - Web-based authentication
- Must support the following Management:
  - SNMP v1, v2c, v3
  - RFC 854 Telnet
  - RFC 1155 Management Information for TCP/IP-Based Internets
  - RFC 1156 MIB
  - RFC 1157 SNMP
  - RFC 1213 SNMP MIB II
  - RFC 1350 TFTP
  - RFC 1643 Ethernet MIB
  - RFC 2030 SNTP
  - RFC 2616 HTTP
  - RFC 2665 Ethernet-Like Interface types MIB
  - RFC 2674 Definitions of Managed Objects for Bridges with Traffic Classes, Multicast Filtering, and Virtual LAN Extensions
  - RFC 2819 RMON MIB
  - RFC 2863 Interfaces Group MIB
  - RFC 3164 Syslog
  - RFC 3414 User-Based Security Model (USM) for SNMPv3
  - RFC 3418 MIB for SNMP

  - RFC 3636 Definitions of Managed Objects for IEEE 802.3 MAUs
  - MIBs
- Must support the following Management Interfaces:
  - Web-based: HTTP/HTTPS
  - Command-line interface: Telnet, SSH, serial port
- Must have the following interfaces and indicators:
  - Uplink: 2 x 1000Base-X transceiver slots
  - LED indicators: link, activity
  - Service Port: 10/100 Mbps Ethernet (RJ45)
  - LED indicators: link, activity
  - Utility Port: 10/100/1000 Mbps Ethernet (RJ45)
  - LED indicators: link, activity
  - Expansion Slots: 1
  - Console Port: RS232 (DB-9 male, DTE interface)
  - Other Indicators: Status, Alarm, Power Supply 1, Power Supply 2

WLAN Control System

The WLAN Management Software must be manufactured by the same vendor providing Core Switches, Access Switches, Unified Communication Components, Wireless LAN Components, Security Components and the Network Management components for feature transparency and compatibility and to guarantee optimum performance.

Must support the following general management:

- Configuration templates
- Bulk provisioning of wireless LAN controllers
- Software management
- User group-based privilege management
- Network auditing
- RADIUS and TACACS+ support for secure access
- HTTP and HTTPS interface

Must provide tools that enable IT managers to visualize the layout of their wireless network and monitor ongoing WLAN performance. This includes detailed heat maps that show RF coverage on top of imported floor plans.
Must facilitates network troubleshooting based on network reports and quick searches for areas such as noise levels, signal-noise ratio, interference, signal strength, clients, controllers, access points, security and performance.

Must provide the following general report features:

- Exporting of reports into comma separated values (CSV) or PDF format.
- Automating and scheduling of exported reports.
- Sending e-mail notifications upon report generation.
- Specifying target or logical entity groups when generating a report.

- Configuring and customizing reports by frequency and polling to reduce the costs of unnecessary network polling and database storage
- Configuring data storage and saving parameters. Hourly aggregated data can be stored for up to 31 days. Daily aggregated data can be stored for up to 90 days. Weekly aggregated data can be stored for up to 54 weeks.

Must have the following features:

- Intuitive GUI and simplified ease-of-use
- Hierarchical maps
- Policy management templates
- Complete wireless LAN intrusion protection
- Secure access
- Client troubleshooting
- Non-Wi-Fi interference detection
- Reporting
- Ease of operation
- Integrated high accuracy location tracking
- Customizable secure guest access
- Wireless LAN planning tools
- Robust APIs
- Support for large scale deployments

42. BAS POINT SCHEDULE

Equipment / Function Description	Manual operator Initiated Command						Universal Indication													Software indication					Remarks
	Quantity	System Display	Start/Stop	Set point Adjust	Alarm Message	Maintenance Message	Temperature	Humidity	Air Quality (CO2)	Flow meter (GPM)	Flow sensor (CFM)	Pressure	Diff. Pressure Switch	kW monitoring	Runtime Toalization	DDC Output 0-10VDC	Run / Normal Status	Trip (Auxiliary Contract)	Auto/Manual	Analog High Limit	Analog Low Limit	Critical Alarm	Maintenance Alarm	Chillier Optimization	
MECHANICAL																									
HVAC																									Obtain all applicable internal data via BACnet software integration with the chillers
Air-Cooled Chillers	3	x	x	x	x	x	x			X		X		x	x		x	x		x	x	x	x	x	
Chilled Water Pumps	3	x	x		x	x							x	x	x		x	x	x			x	x		
Outdoor Temperature & Humidity	1	x					x	x																	
Chilled Water supply and return line	2	x			x	x	x			X		X								x	x				
Chillers 2-way isolation Motorized valve	3	x	x											x									x		
Chilled water bypass Valve	1	x												x		x									
Closed Expansion Tank	1	x										X								x	x	x			
Thermal Storage System	1																								
Tanks Supply and Return Headers		x		x			x													x	x				
Motorized Control Valves		x	x														x					x			
Heat Exchanger Inlet Headers		x					x													x	x				
Heat Exchanger Outlet Headers		x					x													x	x				
Heat Exchanger Pumps		x			x	x									x			x				x	x		
Thermal Tank Pumps		x			x	x									x			x				x	x		

BAS POINT SCHEDULE

Equipment / Function Description	Manual operator Initiated Command						Universal Indication													Software indication					Remarks
	Quantity	System Display	Start/Stop	Set point Adjust	Alarm Message	Maintenance Message	Temperature	Humidity	Air Quality (CO2)	Flow meter (GPM)	Flow sensor (CFM)	Pressure	Diff. Pressure Switch	kW monitoring	Runtime Toalaization	DDC Output 0-10VDC	Run / Normal Status	Trip (Auxiliary Contract)	Auto/Manual	Analog High Limit	Analog Low Limit	Critical Alarm	Maintenance Alarm	Chillier Optimization	
MECHANICAL																									
HVAC																									
Air handling unit (with VFD)	10																								
Supply Duct	10	x		x			x													x	x	x			
Return Duct	10	x					x	x	x											x	x	x			
Supply Fan	10	x	x		x	x							x	x	x	x		x	x			x	x		
Supply duct static pressure	10	x										X								x	x	x			
Electric Heater	2	x	x		x	x							x		x			x				x			
2-way Cooling valve	8	x														x									
Supply duct smoke detector	10	x			x												x					x			
Fire signal from F.A System	2	x			x												x					x	x		
Filters	10	x			x	x							x										x		
Motorized Outside air damper	6	x	x														x								
Supply duct Air flow measuring Station	10	x									x					x	x								
MECHANICAL																									
VAV Boxes																									
Zone thermostat with LCD display		x					x													x	x	x	x		
Damper control		x	x																						
Air Flow at each box		x									x														

BAS POINT SCHEDULE

Equipment / Function Description	Manual operator Initiated Command						Universal Indication												Software indication						
	Quantity	System Display	Start / Stop	Set Point Adjust	Alarm Message	Maintenance Message	Voltage	Ampere	Kilo Watt	kW hour	Frequency	Power Factor	T. harmonic distortion		Runtime totalization		On Status	Trip alarm	Auto / Manual	Analog High Limit	Analog Low Limit	Critical Alarm	Maintenance Alarm	Chiller Optimization	Remarks
ELECTRICAL																									
Lighting DB's	16	x	x			x											x								Hardwire connection
Main Fuel Tank	1	x															x					x	x		Hi/Low Level Alarm
Daily Fuel Tank	1	x															x					x	x		Hi/Low Level Alarm
Fuel Pump	2	x															x	x				x	x		
Water Leak detection system under Raised Floor: -																									
1) First Floor	1	x				x											x					x	x		
2) Under Raised Floor	1	x				x											x					x	x		
3) Third Floor	1	x				x											x					x	x		

BAS POINT SCHEDULE

Equipment / Function Description	Manual operator Initiated Command						Universal Indication												Software indication					Remarks
	Quantity	System Display	Start / Stop	Set Point Adjust	Alarm Message	Maintenance Message	Voltage	Ampere	Kilo Watt	kW hour	Frequency	Power Factor	T. harmonic distortion		Runtime totalization		On Status	Trip alarm	Auto / Manual	Analog High Limit	Analog Low Limit	Critical Alarm	Maintenance Alarm	Chiller Optimization	
ELECTRICAL																									
Lighting DB's	16	x	x			x											x								Hardwire connection
Main Fuel Tank	1	x															x					x	x		Hi/Low Level Alarm
Daily Fuel Tank	1	x															x					x	x		Hi/Low Level Alarm
Fuel Pump	2	x															x	x				x	x		
Water Leak detection system under Raised Floor: -																									
1) First Floor	1	x				x											x					x	x		
2) Under Raised Floor	1	x				x											x					x	x		
3) Third Floor	1	x				x											x					x	x		

GOVERNMENT OF KUWAIT

MINISTRY OF ELECTRICITY AND WATER

CONSTRUCTION AND MAINTENANCE OF 5 NOS. R.C. GROUND RESERVOIRS FOR FRESH WATER, 55 M.I.G CAPACITY EACH, AND ANNEXED WORKS AT MUTLA HIGH (STAGE-II)

SECTION – 4E

TECHNICAL SPECIFICATION FOR BUILDING WORKS

PRELIMINARIES

EXCAVATION

CONCRETOR

BRICKLAYER AND MASON

PLASTERER

PAVIOR, MARBLE AND TERRAZZO WORKER

ROOFER

CARPENTER

JOINER

IRONMONGER

METAL WORKER

DRAINLAYER

PLUMBER

GLAZIER

PAINTER

SECTION 4E
TECHNICAL SPECIFICATION FOR BUILDING WORKS

PRELIMINARIES

4E.1 MATERIALS:

All materials are to be the best of their respective kinds and in accordance with the latest relevant Kuwait Standards where these exist, otherwise to British Standard Specifications or approved equivalents. The Contractor shall sumbit to the Engineer, samples of all materials which he proposes to incorporate into the Work sufficiently prior to such incorporation so that the Engineer may be able to obtain results of all or any test he proposes to be carried out on such samples. All materials used into the Works thereafter shall fully conform to such approved samples.

4E.2 DRAWINGS AND SPECIFICATIONS:

The Contractor is to familiarize himself thoroughly with all drawings and specifications issued to him and shall carry out the work in accordance with the true intent and meanings thereof.

4E.3 DATUM:

The datum levels will be determined on Site by the Engineer. Any checking or approval by the Engineer or his representatives does not relieve the Contractor from his responsibilities under the Contract.

4E.4 WORKING AREA:

The Contractor will be given an area, reasonably large enough to carry out all his activities within the Site of the Works. He shall confine his operations within such working area as allotted to him and shall not encroach upon, occupy, use, and / or extend his operations beyond the Site of the Works without the Engineer's written consent.

4E.5 STORAGE OF MATERIAL:

The Contractor shall erect and maintain proper stores for the storage of all materials to be used in construction of the Works. The stores shall be strongly constructed and shall be weather tight, secure and capable of protecting the

materials from deterioration and theft. The Contractor shall submit to the Engineer his proposal for the stores before construction is commenced.

Cement shall be delivered to the Site in sealed bags or water-tight barrels bearing Name of the manufacturer and the date of manufacture. The cement shall be stored in perfectly dry waterproof sheds or other such temporary buildings approved by the Engineer.

These buildings shall be used exclusively for the storage of cement and shall be erected at locations on or near the site of the Works with floor raised well above ground level. On completion of the Works the temporary buildings shall remain the property of the Contractor and shall be dismantled and removed, the foundations broken up, etc., and the Site restored to its original condition at the Contractor's expense. A free passage of at least one metre shall be left between the cement and the side walls of the sheds. Access ways shall also be left between the stored bags of cement such that every bag is visible. Each consignment of cement shall be stored apart from earlier consignments and consignments shall be used in the order in which they are delivered. Any consignment which has become caked or otherwise adversely affected shall be removed from the site immediately at the Contractor's own expense.

The Contractor shall provide weighing machines which shall be kept permanently in each shed for checking the weight of the bags or barrels of cement. The Engineer shall have access at all times to the cement storage sheds.

During transport and storage, the cement shall be fully protected from all weather elements. The temperature of the cement entering the mixers shall not exceed 45 °C.

4E.6 CONTRACTOR'S PLANT & METHOD OF WORKING:

All mechanical excavators, pumps, concrete mixers, concrete distributing and conveying plant and all other mechanical plant used by the Contractor in the execution of the Works shall be of such types and sizes and shall be used in such manner as is acceptable to the Engineer. The Contractor will be responsible for obtaining all such plants.

The method of working to be adopted by the Contractor shall be approved by the Engineer, but any approval that may be given shall not relieve the Contractor of his responsibility for proper execution and safety of the Works.
If circumstances arise which, in the opinion of the Engineer, necessitate a change in the Method of the Working, or the suspension of the use of the plant or part of the plant, either temporarily or permanently and notwithstanding the previous approval

by the Engineer of the type, size and manner of using such plant, or of the previous use of such plant, either on the affected portion of the Works, or on any other portion of work, the Contractor shall immediately adopt another approved Method of Working, with or without other approved plant and shall have no claim against the Employer or Engineer for costs incurred by him in changing the Method of Working, or in the provision or use of other such plant.

4E.7 VARIATION IN METHOD OF CONSTRUCTION:

where a method of a construction for a particular section of work is detailed or specified in the Contract Documents or is reasonably inferred there from, the Contractor shall at all times, observe such method of construction unless he shall have previously obtained the approval of the Engineer to an alternative method of construction.

EXCAVATION

4E.8 DATUM AND NATURE OF EXCAVATION:

The datum for the Site shall be that shown on the drawing otherwise, it shall be that of the 'Local Survey Grid, of the Municipality of Kuwait'. Information pertaining to the nature of the ground may be given to the Contractor, when available, but without any guarantee of correctness or accuracy.

4E.9 EXCAVATION:

a. As soon after the signing of the contract as possible, the contractor shall carry out the soil investigations stipulated hereunder for the purpose of checking that the subsoil conditions at the precise locations of their proposed structures and are in accordance with the subsoil conditions assumed for the design of the structures. Until such investigations have been completed and the results considered by the Engineer, the design of the foundations to the structure must be considered as preliminary and subject to the alternation and no work on the foundations shall be commenced until the written instructions of the Engineer to this affect have been received by the contractor. The preliminary design of the foundations has been carried out on the basis of the soil investigations detailed in Appendix hereto and it is not anticipated that major redesign of the foundation structures will be necessary.
   Also, until the issue of the Engineer's instructions to commence foundation work, no excavation deeper than 0.5 m above the proposed foundation level shall be permitted and so that the moisture content of the sub grades shall not be disturbed. This top layer shall be continuously kept moist by water spraying or any other methods the Engineer may consider necessary. No sub grade may at

any time be exposed to the atmosphere before proper arrangements have been made for immediate pouring of the blinding concrete.

In accordance with the foregoing, the following sub-soil check investigations including chemical analysis of soil shall be carried out by the contractor at his own expense and care shall be taken to ensure that the number of investigations stated shall be made accurately over the precise locations of the proposed structures at the sites specified in particular specification.

b. The Contractor shall carry outthe necessary excavation work in any type of ground which is likely to be encountered, such as hard or soft gatch, shale, clay, quicksand, running sand, sandstone, limestone, rock or in any other type of material including asphalt to profiles as shown on the drawings or as instructed by the Engineer.

c. The excavated material is to be disposed off in the manner agreed and approved by the Engineer and all surplus is to be carted away to a place as approved by the Ministry.

d. The Contractor is solely responsible for the safety of the excavations and he shall provide all necessary planking and strutting required in the manner and method agreed by the Engineer.

e. All excavations shall be kept free from water by pumping, bailing, sub-drains, and sumps, as required, at the Contractor's expense unless otherwise described in the Bill of Quantities.

f. The face and beds of all excavations shall be properly trimmed and all loose mud, dirt, sand, and debris cleared away.

g. All excavations shall be inspected and approved by the Engineer prior to laying of any blinding or plain concrete for foundations.

h. The Contractor shall take all necessary precautions against risk of subsidence, slips, falls, and all other damage to excavations.

i. In the case of shoring excavations, the sides shall be supported as necessary to maintain a vertical face and to prevent caving-in of any nature, especially during subsequent operations. The Contractor shall be responsible for the design, supply, fixing, safety, and removal of all planking, strutting and shoring required to the side of the excavations. Excavations having un shored near vertical or vertical sides shall be backfilled without undue delay.

4E.10 BACKFILLING:

Any excavated materials approved by the Engineer as suitable for backfilling shall be kept in separate spoil heaps.

Additional materials required for backfilling shall be gatch bound sand obtained by the Contractor in conformity with the samples approved by the Engineer.

The materials for backfilling are to be taken from the approved spoil heaps or imported gatch. Backfilling shall be deposited in regular successive layers not exceeding 150 mm (six inches) thick, wetted and rammed by approved means, to the required levels and grades and to the satisfaction of the Engineer.

Any excavations carried out by the Contractor to greater depths than shown on the drawings or described in the Bills of Quantities shall be back filled with concrete C10 mix to the specified level, at the Contractor's own expense.

Water for use in compacting fill material on Site shall be fresh water.

4E.11 APPROVAL:

The Contractor shall obtain approval from the Engineer of the excavations before commencing concrete works.

4E.12 REINSTATEMENT:

On completion of the Contract, the Contractor shall reinstate all disturbed land surfaces whether within or without the cartilage of the Site at his own expense and to the satisfaction of the Engineer.

4E.13 EXPLOSIVES:

The use of explosives to remove rock within the course of excavations will not be allowed without the prior written consent of the Engineer. The Contractor shall entirely be responsible for all safety precautions concerned with the use of explosives.

CONCRETOR

4E.14 CEMENT:

The cement shall be port land cement type I for above the ground works unless otherwise mentioned in the particular specifications or in the Bill of Quantities.

Sulphate resistant cement type V shall be used for underground works conforming in all respects to A.S.T.M C150, except that bags shall contain 50 kg. net ±1% (One percent) and barrels or containers shall contain multiples thereof.

One brand of cement as approved by the Engineer shall be used for all concrete works throughout the project unless otherwise authorized by the Engineer in writing.

If the content of alkali, $Na_2O + 0.658\ K_2O$, is greater than 0.6 calculated as $Na_2 + K_2O$, in the type V cement, tests shall be carried out according to A.S.T.M. C227 with the aggregates to be used.

The source of supply of cement shall be subject to the Engineer's approval and the Contractor shall at all times furnish the manufacturer's test certificates and proof that the required standard specification has been complied with together with a note of the date of manufacture, certified by an independent agency in the country of origin. The Engineer shall have the power to reject a part or the whole of any consignment of cement if he considers it to be unsuitable for use in the Works.

4E.15 AGGREGATES:

This Specification covers fine and coarse aggregates other than light weight aggregates for use in the production of concrete. When lightweight aggregates are required, they shall be defined in the Particular Specification.

The Aggregates shall be naturally occurring materials, crushed or uncrushed, and shall generally conform to BS 882 'Aggregates from Natural Sources for Concrete'.

For convenience, part of Clause 5 of BS 882 (Grading) including Tables 1, 2 and 3 are reproduced herein.

a. Coarse Aggregate:

The grading of coarse aggregate, when analyzed by the method given for sieve analysis in BS 812 shall be within the limits given in Table 1.

TABLE (1). COARSE AGGREGATE (Percentage by weight passing BS Sieves).

BS* Test Sieve in mm	Nominal Size of Graded Aggregate/			Nominal size of Single-sized aggregates.			
	40mm to 5mm	20mm to 5mm	14mm to 5mm	40 mm	20 mm	14 mm	10 mm
50.-	100	-	-	100	-	-	-
37.5	90-100	100	-	85-100	100	-	-
20.00	35- 70	90-100	100	0- 25	85-100	100	-
14.00	-	-	90-100	-	-	85-100	100
10.00	10- 40	30- 60	50- 85	0- 5	0- 25	0- 50	85-100
5.00	0- 5	0- 10	0- 10	-	0- 5	0- 10	0-100
2.36	-	-	-	-	-	-	0- 5

* BS 410 'Test sieves' Part 1, 'Fine and medium test sieve (woven wire)' part 2, 'Coarse test sieves (perforated plate).

b. **Fine Aggregate:**
The grading of a fine aggregate, when analyzed by the method of sieve analysis described in BS 812, shall be within the limits given in Table 2, (C or M).

The fine aggregate shall be described as fine aggregate of the grading limit into which it falls, e.g. BS 882, Grading Limit C.

NOTE:
It is intended that individual limits should not be specified in Contract Documents relating to concrete but that the concrete mixes should be modified to make the best of the materials readily available.

TABLE (2). **FINE AGGREGATE**

BS 410 Sieve size	Percentage by mass passing BS sieve			
	Overall Limits	Additional limits for grading		
		C	M	F
10.00 mm	100	-	-	-
5.00 mm	89-100	-	-	-
2.36 mm	60-100	60-100	65-100	80-100
1.18 mm	30-100	30- 90	45-100	70-100
600 microns.	15-100	15- 54	25- 80	55-100
300 microns.	5- 70	5- 40	5- 48	5- 70
150 microns.	0- 15	-	-	-

All in aggregate to BS 882, Table 3, and crushed stone sand, shall not be used for reinforced concrete but may be used for mass concrete, if approved by the Engineer. Single-Sized aggregate to BS 882. Table 1 may only be used for reinforced concrete when combined in two or more sizes to provide a well graded mixture approved by the Engineer.

Sampling and testing of aggregates shall be as required by BS 882, and in accordance with BS 812 "Methods for sampling and Testing of Mineral Aggregates, Sand, and Fillers". All sampling shall be done by or under the supervision of the Engineer.

The grading of sieve analysis described in BS 812, shall be in accordance with Table 3.

TABLE (3). **ALL IN AGGREGATE**

All-in aggregate			
Sieve size	Percentage by mass passing BS sieves		
	40 mm nominal size	20 mm nominal size	10 mm nominal size
50.0 mm	100	-	-
37.5 mm	95-100	100	-
20.0 mm	45-80	95-100	-
14.0 mm	-	-	100
10.0 mm	-	-	95-100
5.00 mm	25-50	35-55	30-65
2.36 mm	-	-	20-50
1.18 mm	-	-	15-40
600 micron.	8-30	10-35	10-30
300 micron.	-	-	5-15
150 micron.	0-8*	0-8*	0-8*
* Increased to 10% for crushed rock fines.			

4E.16 HANDLING AGGREGATES:

The choice and preparation of sites for stockpiling of aggregates, the number and sizes of stockpiles and the method adopted to provide segregation of component sizes shall be agreed with the Engineer.

Coarse aggregate shall be stockpiled in three separate grading: 38-19 mm (1.1/2 - 3/4 inch), 19-10 mm (3/4 - 3/8 inch), 10-5 mm (3/8 - 3/16 inch). When aggregates of different grading are stockpiled close together, the stockpiles shall be separated by bulkheads.

Stockpiles shall be made on concrete or other hard surface sufficiently sloped so that water is not retained in the base of the stockpiles.

All aggregates shall be handled from the stockpile, in such a manner as to secure a typical grading of the material, care being taken to avoid crushing the aggregates or contaminating them with extraneous matter.

Aggregates need not be stockpiled when a crushing screeding plant is used in tandem with a batching plant properly equipped with several bins for different sized aggregates having the appropriate weighing scales at each bin such that a mix of the desired gradation is obtained consistently and the whole operation is conducted to the satisfaction of the Engineer.

4E.17 PHYSICAL AND CHEMICAL PROPERTIES FOR AGGREGATE:

The physical and chemical properties for coarse and fine aggregate shall be according to Table (4)

4E.18 TESTING OF AGGREGATE:

Both coarse and fine aggregates, either already delivered to Site or which the Contractor proposes to deliver, shall not be incorporated into the Works until the Engineer has had sufficient time to obtain results of any tests which he proposes to be carried out by the Govt. Research Station.

The Contractor shall provide samples of both coarse and fine aggregates in such quantities as shall be required for testing purposes.

4E.19 WATER:

Water to be used for mixing, curing and washing of aggregates shall not contain organic matter, acids, excessive sulphates, chlorides or other salts in such quantities as to cause efflorescence on the face of the concrete, nor adversely affect the setting time nor strength of the concrete, nor to instigate electrochemical corrosion of the reinforcement.

Fresh water, potable water, or water containing not more than 2000 parts per million of dissolved solids of which no more than 1000 may be chlorides, should be used for all concrete work. In general the mixing water shall comply with BS 3148.

Water / Cement Ratio.

The term water / cement ratio means the ratio by weight of the water to the cement in the mix, expressed as a decimal fraction. The water is that which is free to combine with the cement in the mix. This includes free water in the aggregate but excludes water absorbed or to be absorbed by the aggregate.

The aggregate for this purpose shall be taken in a surface-dry condition.

The absorption of the aggregates shall be determined in accordance with BS 812.

Aggregate / Cement Ratio.
The term aggregate / cement ratio means the ratio by weight of aggregate to cement in the mix. For this purpose the aggregate is taken in a saturated surface-dry condition as for the water / cement ratio above.

Fine / Total Aggregate Ratio.
The term fine / total aggregate ratio means the ratio by weight of the fine aggregate to the total aggregate in the mix expressed as a percentage. For this purpose the aggregate is also taken in a saturated surface-dry condition as for the water / cement ratio above.

Volume of Air entrained.
The air content expressed as percentage by volume of concrete, shall be determined by ASTM method C231 'Air Content of Freshly Mixed concrete by the Pressure Method'. At least one test for each 120 cubic meters of concrete shall be made.

Slump.
The slump of the freshly mixed concrete shall be determined in accordance with PART 102 OF BS 1881 OR ASTM C143. At least one morning and one afternoon test shall be made and in addition whenever directed by the Engineer.

Strength of Concrete.
Designed to select the job mix and shall be made and tested in accordance with parts 6 and 8 of BS 1881. Works Test Cubes shall be made and tested in accordance with BS 1881.

4E.20 MIX PROPORTION:

The designed concrete mix shall meet the appropriate standard requirement for the water / cement ratio, the minimum for cement content and shall be of good workability as tested by the slump test at Site

4E.21 ADJUSTMENT OF MIX PROPORTIONS:

The Contractor when tendering (having knowledge of the source and type of cement, aggregates plant and method of placing he intends to use) shall allow for the aggregate / cement ratio which he considers will achieve the strength requirements

specified and will produce a workability which will enable the concrete to be properly compacted to its full depth and finished to the dimensions and within the tolerances shown on the drawings and required by the Particular Specification. In any event, the water / cement ratio shall not exceed the upper limits specified in Table.5 below for each type of concrete. Furthermore, the quantity of cement per cubic meter of concrete shall in no case be less than the minimum specified in Table 5, below.

TABLE (4). **PHYSICAL AND CHEMICAL PROPERTIES FOR AGGREGATE**

Property	Maximum & Minimum Allowable		Standard	
	Fine Aggr.	Coarse Aggr.	Allowable Limits	Test Method
Grading	Table 2	Table 1	BS Tables 4, 5 & 6	BS 812 Part 1
Organic Impurities in Fine Aggr. for Concrete.	See note (3)	-------	ASTM C - 33	ASTM C - 40
Materials Finer Than 75 um Sieve.	3% Max.	1 % Max.	BS 882	ASTM C - 1 17 or BS 812Part1
Clay Lumps and Friable Particles in Aggr.	3% Max.	3% Max.	ASTM C - 33	ASTM C - 142
Lightweight Pieces in Aggr. (Coal and Lignite).	1% Max.	0.50% Max.	ASTM C - 33	ASTM C - 123
Chert (Less Than 2.4 sp. gr. SSD).	-------	5% Max.	ASTM C - 33	ASTM C - 123 ASTM C - 295
Apparent Specific Gravity.	2.4% Min.	2.4% Min.	-------	ASTM C - 127 ASTM C - 128
Water Absorption.	3% Max.	3% Max.	-------	ASTM C - 127 ASTM C - 128
Soundness (5 cycles) :- A-Sodium Sulfate. B-Magnesium Sulfate.	10% Max. 15% Max.	12% Max. 18% Max.	ASTM C - 33	ASTM C - 88
Chloride Content.	0.04% Max. by mass of coarse and fine agg. or 0.4% Max. by mass of cement in the mix.		BS 882 BS 8110 Part 1	BS 812 Part 117
Soluble Sulphate Content - S03	4% Max. by-mass of the cement in the mix		BS 8110 Part 1	BS 812 Part 118
Fines Value - 10%	-------	50 KN Min. - (2)	BS 882 Tab. 3	BS 812 Part 3
Impact Value.	-------	45% Max. - (1-)	BS 882 Tab. 3	BS 812 Part 3
Resistance to Degradation of Coarse Agg.	-------	50% Max.	ASTM C - 133	ASTM C - 131 ASTM C - 535
Flakiness Index.	-------	35% Max.	BS 882	BS 812 Part 1
Shell Content.	-------	8% Max.	BS 882	BS 812 Part 1

NOTES :-

(1) Max. 30% for Concrete Wearing Surface.

(2) Not less than 100 KN for aggregate used in Concrete Wearing Surface

(3) A fine aggregate failing in the test may be used provided that, when tested for the affect of organic impurities on strength of mortar, the relative strength at 7 days calculated in accordance with Test Method C87, is not less than 95%

TABLE (5). GENERAL REQUIREMENTS FOR TYPES OF CONCRETE.

Type of Concrete	A	H	C	D	Mass
Water/Cement Ratio	.4 - .45	.45 - .50	.50 - .55	.55 - .65	150 - 200
Cement Kg/m3 of concrete	400 - 500	300 - 400	250 - 300	200 - 250	
Slump max. in cm.	8 - 10	8 - 10	8 - 10	8 - 10	10 - 12
Prelim. Test Cube min Compressive strength at 28 days (Mpa)	40	30	25	17.5	9
Cube min. Compressive strength at 28 days (Mpa)	32.5	25	20	15	7
Concrete compaction method	Vibrate	Vibrate	Vibrate	Vibrate / Rodded	Rodded / Tamped

The strengths specified are for ordinary port land cement Type I cement to ASTM C150. If other types of cement are specified, the required strength shall be defined in the Particular Specification.

In case cylinders are used for the determination of concrete compressive strength in accordance with ASTM 39, the corresponding cube strengths shall be obtained by using a multiplication of 1.2.

As soon as possible after signature of the Contract, the Contractor shall prepare such trial mixes as required to satisfy the Engineer that the specified concrete strengths will be obtained using the materials and mix proportions in accordance with the above Clauses. The proportions of cement shall be increased if necessary to obtain the strengths and / or workability required.

From each trial mix, six preliminary Test Cubes shall be made and tested three at 7 days being intended to give an early indication of possible variation from the required strength. If the difference between the highest and lowest test results from any one trial mix is more than 15 percent of the average of the strength test results, the test is to be discarded and a further trial mix made, unless all test results so obtained are above the required strength.

Separate trial mixes are required for each type of concrete. The trial mix or mixes agreed by the Engineer shall be designated the "job mixes" and used as a basis for actual concrete production.

4E.22 BATCHING AND MIXING OF CONCRETE:

All concrete shall be batched by weight and mixed mechanically. Hand mixing shall not be allowed. Batching of aggregate by volume may be allowed only upon the written permission of the Engineer.

Concrete may either be batched and mixed on Site or off the site and transported thereto.

When mixed off the Site and transported to it, batching and mixing shall be in accordance with ASTM Specification C94 "Standard Specification for Ready-Mixed Concrete".

When mixed on Site, batching and mixing shall be as follows:

Batching by Weight.

The cement and each size of aggregate shall be measured by weight. The water may be measured by weight or volume. The weight-batching machines used shall be of a type approved by the Engineer and shall be kept in good condition while in use on the Works. Checks are to be made, as required by the Engineer, to determine that the weighing devices are calibrated according to the tolerances described in AC1 301.

Batching Aggregate by Volume.

When batching aggregates by volume is allowed, as and when required, the cement shall be batched by weight and the water by weight or volume. Each size of aggregate shall be measured in metallic containers the depth of which is at least equal to their greatest width. The containers shall be of such shape that their volume can be easily checked by measurement.

Mixing Concrete.

The location of the batching and mixing plant shall be agreed with the Engineer.

Concrete shall be mixed in a batch mixer of a type approved by the Engineer and in good condition having a drum rotating about a horizontal or inclined axis. Continuous mixers shall not be used. Each mixer is to be fitted with a water measuring device the accuracy of which will not be affected by variations in the water supply pressure.
About Ten percent (10%) of the water required for the batch shall enter the drum in advance of the cement and aggregates. The remainder of the water

shall then be added gradually while the drum is in motion so that all the required water shall be in the drum by the end of the first quarter of the mixing time. The concrete shall be mixed until a mixture of uniform color and consistency is obtained. Where double-drum, high performance mixers of a type approved by the Engineer are used, a minimum mixing time of 70 sec. may be allowed.

The amount of concrete mixed in any one batch is not to exceed the rated capacity of the mixer. The whole of the batch is to be removed before materials for a fresh batch enter the drum.

On cessation of work, including all stoppages exceeding 20 minutes, the mixers and all handling plant shall be washed with clean water. If old concrete deposits remain in the mixer drum it shall be rotated with clean aggregate and water prior to production of new concrete.

Concrete mixed as above is not to be modified by the addition of water or in any other manner to facilitate handling or for any other reason.

Work in Cold or Hot Weather.

Concrete is not to be mixed or placed at a shade air temperature below 2°C on a rising Thermometer or at a shade air temperature below 3°C on a falling thermometer.

When the shade air temperature is 37°C and rising, special precautions shall be taken during concreting operations, such as shading of the aggregates and plant, cooling of the mixing water or other methods approved by the Engineer, so that the temperature of the concrete when placed shall not be in excess of 30°C.

Fresh concrete place at these temperatures shall be shaded from the direct rays of the sun to the satisfaction of the Engineer for a period of at least 24 hours.

Concrete is not to be mixed and placed when the shade air temperature is 40°C or above.

4E.23 REINFORCEMENT:

Steel reinforcement shall be High tensile smooth round bars complying with BS 4449, BS 18 part (2) and BS 4482 or similar approved standard.
Hot Rolled high yielding deformed bars with ASTM 615 Grade 60 with min. yield strength of fy= 4200 Kg/cm^2 .

Manufacturer's test certificates for all classes of reinforcement shall be supplied when required. Specimens sufficient for three tensile tests and three cold bend tests per ten tons of bars or fraction thereof and for each different size or bar shall be sampled under the supervision of the Engineer. Testing shall be in accordance with BS 4449 and BS 4482 or other approved standard and batches shall be rejected if the average results for each batch are not in accordance with the Specifications.

All steel is to be totally free from dirt, oil, paint loose rust or scale when in position ready for concreting.

The bars are to be accurately bent to the shapes indicated, and the bending must, whenever possible, be completed before the steel is fixed in position. Straight portions of bars must be true and bends must be kept out of winding. The internal radius of bends shall in no case be less than four times the diameter of the bar, except for stirrups, column binders, and wall shear bars which are to be bent to fit closely around the main bars. Great care is to be taken to bend stirrups column binders, and wall shear bars which are to be bent to fit closely around the main bars. Great care is to be taken to bend stirrups and binders separately and to the sizes shown. In the absence of reinforcement bending schedules, the bending requirements of BS 4466 "Bending Dimensions of Bars for Concrete Reinforcement" or other similar approved standard shall govern.

Except as otherwise allowed by the Engineer, bars are to be bent cold.

Lengthening of bars by welding, and re bending of incorrectly bent bars will not be permitted, except where requested by the Engineer.

Unless otherwise allowed for in the Particular Specification splices in reinforcing bars shall be formed by lapping. Such laps in bars in any member shall be staggered. Except as otherwise indicated on the Drawings, the minimum overlap of lapped splices shall be 40 bar diameters or 30 cm., whichever is greater.

Mixing of Mild steel and H.T. is not allowed.
Special steel for pre stressed concrete to be specified in the Particular Specification.

The steel is to be fixed in position exactly as indicated, and the bars are to be securely wired together with 1.6 or 1.4 mm dia. soft iron wire not less than No.16 gauge or approved spring steel clips wherever necessary to prevent any displacement during concreting. Spacers, chairs, and the like, temporary or permanent are to be used as required to ensure that the steel has the exact amount of cover indicated. No permanent spacers may show on a surface where a fair faced concrete finish or a

brushed aggregate finish is required.

Unless otherwise indicated, the minimum cover to reinforcing bars shall be as follows:

POSITION.	MINIMUM COVER.
Main bars in internal faces of Columns and beams.	25
Main bars in external faces of columns and beams.	35
Main bars in floor slabs and soffits of roof slabs.	15
Main bars in top of roof slabs outermost bars in internal faces of walls.	20
Outermost bars in internal faces of walls.	15
Outermost bars in external faces of walls.	25
Bars in top of ground slabs.	20
Bars near faces in contact with soil.	50

The placing of all reinforcement shall be checked by the Engineer and in no case is concrete to be poured around any steel that has not been passed by him. The Contractor is to ensure that no steel is displaced from its position during the placing of concrete and until the concrete has set.

The insertion of bars into or the removal of bars from concrete already placed will not be permitted. Reinforcement temporarily left projecting from the concrete at the joints shall not be bent without the prior approval of the Engineer.

Secondary reinforced concrete members for which no reinforcement details are given in the Drawings or the Particular Specifications shall have a minimum ratio of reinforced concrete area to plain concrete area of half percent (0.5%).

Weights and dimensions of bars shall be as per specification (BS 4449), but for the diameters which are not mentioned in this specification, the requirements in the following table shall be fulfilled:

Diameters	Cross Sec. Area (mm^2)	Tolerance in Weight Kg/mm^2 .	Tolerance in Weight Kg/mm^2	
			For Group of Bars	For Single Bar
14	153.9	1.208	± 2.5%	± 4.5%
18	254.3	2.000	± 2.5%	± 4.5%
22	380	2.983	± 2.5%	± 4.5%
28	616	4.837	± 2.5%	± 4.5%

4E.24 FORMWORK:

The Contractor shall supply, design, erect, strike, and remove the formwork and be

entirely responsible for its stability and safety so that it will carry the wet concrete and all incidental loadings, and preserve it from damage and distortion during its placing, vibration, ramming, setting, and curing. It shall be so constructed as to leave the finished concrete to the dimensions shown on the Drawings and of a material capable of providing the surface finish as specified. In any event, the maximum permissible deflection under all loads shall not exceed 2 mm or 1/600 of the free span, whichever is less.

Formwork shall be constructed so as to prevent the loss of any liquid from the wet concrete, and to be removable without shock to the partially set concrete. When the concrete is to be vibrated, all wedges must be nailed so as to prevent slipping or distortion.

Formwork shall be of timber and / or metal type and shall include all temporary concrete moulds type and their supports.

For concrete surfaces which are to be plastered, clean sawn boarding shall be used.

For concrete surfaces which are to remain exposed, wrought formwork shall be used. Wrought formwork shall be of timber framing lined with 12 mm thick smooth faced plywood or an equaling approved by the Engineer, or of metal, suitable to obtain a fair face finish on the concrete. Where columns and beams are shown as chamfered a minimum of 1.5 x 1.5 cm. wrought hardwood fillet shall be planted in the angles of the formwork or as shown on the Drawings.

All formwork is to be thoroughly cleaned of any old concrete or any other deposits. Immediately before concreting it shall be thoroughly hosed down with water, temporary openings being provided to permit the escape of sawdust, shavings, etc., with the water.
Wherever required and prior to placing of the reinforcement, the internal surfaces of all formwork shall be treated with an approved mould oil.

All formwork shall be inspected and approved by the Engineer prior to concreting. This approval, however, does not relieve the Contractor of his responsibilities.

Unless otherwise specified, the minimum periods before striking formwork and centering shall be as follows:

Columns ……. … 2 days.
Beams sides ……..2 days.
Beams soffits …….. ……14 days.
Walls …… 4 days.
Suspended slabs, soffits ……7 days.

Props to slabs …….. 14 days.
props to beams ……..21 days.

Any work showing signs of damage through premature loading is to be entirely reconstructed at the Contractor's expense.

The responsibility for the safe removal of the formwork rests with the Contractor. However, the Engineer has the right to fix the time of striking if he decides this to be beneficial to the work.

4E.25 PLACING:

Concrete shall be conveyed from the mixer to its final position in any suitable manner, provided there is no segregation, loss of ingredients, or contamination. It shall be placed in its final position before initial setting takes place and within 20 minutes of the addition of the water to the mixer. However, when agitating equipment is used to convey concrete such as in ready-mixed concrete the elapsed time between the addition of the water and placing may be increased to 45 minutes, if accepted by the Engineer.

The order of placing concrete shall be such as to prevent water from collecting at the ends, corners and along the faces of the forms. It shall not be placed in large quantities at a given point and allowed to run or be worked over a long distance in the forms. Whenever possible, concrete shall be placed and compacted in even layers with each batch adjoining the previous one.

The thickness of the layers shall be between 15 and 30 cm. for reinforced concrete and up to 45 cm. for plain (non-reinforced) concrete, the thickness depending on the width of the forms, the amount of reinforcement and the need to place each layer before the previous one stiffens.

Concrete shall not be allowed to drop freely for more than 150 cm. In order to convey the concrete as near as possible to its final position, drop chutes of rubber or metal shall be used for small sections and bottom dump buckets or other suitable vessels for large sections of concrete work.

Concrete shall be carefully compacted when placed to ensure a dense and uniform mass free from air holes and cavities. Concrete types 'A', 'B' and 'C' shall be compacted by vibration, whereas type 'D' and Mass concrete may be vibrated or rammed, tamped, and rodded. Vibration shall be performed by mechanical, or electro-mechanical vibrators. The vibrators shall be of the plunger (Poker) type for insertion in the concrete; plate type vibrators (external) shall be used if so required by the Engineer.

The plunger type vibrators shall have a diameter compatible with the spacing of reinforcement, a sufficiently high frequency and be properly handled by experienced personnel. They shall be immersed at regular intervals close enough to vibrate all of the concrete, but not too close to affect previously vibrated and partially set concrete. Each immersion shall continue until shortly after air bubbles cease to appear on the surface of the concrete, but shall not last more than 30 seconds. The vibrators shall be withdrawn gradually and vertically to ensure that no air pockets are formed. When external vibrators are used as directed by the Engineer, they shall be clamped to the forms whenever possible to avoid large impact during handling, and the forms shall be so constructed as to withstand the additional vibrations.

All vibration, compaction and finishing operations shall be completed within 15 minutes from the time of placing the concrete in its final position.

Workers shall not be allowed to walk over freshly placed concrete until it has hardened sufficiently to carry their weight without distortion.

Concreting of any one part or section of the work shall be carried out in one continuous operation, and no interruption of concreting work will be allowed without the approval of the Engineer. Where beams and slabs together form an integral part of the structure, they shall be poured in one operation, unless provision is made to form a construction joint.

A record is to be kept by the Contractor on Site of the time and date of placing the concrete in each portion of the Works and the number and identification of the Works Test Cubes corresponding to these portions. Such records are to be handed to the Engineer weekly during the progress of the Work.

If the placing of concrete by pumping is required it shall be specified in the Particular Specification.

4E.26 RETARDERS AND ADMIXTURES:

No admixtures of any type shall be used in preparation of concrete unless so required by the Particular Specification or unless so directed by the Engineer. In case any such admixtures are used the rates and methods of application shall be strictly in accordance with the manufacturers instructions and Trial Test Results.

To avoid, 'cold joints', the Contractor shall provide sufficiently large capacity in his concrete producing plant and concrete transporting arrangements or use an appropriate retarder. Should the Contractor elect to use a retarder then such

retarder shall be of a type approved by the Engineer and shall conform to the requirements of type A or D as specified in ASTM C494. The Contractor shall be entirely responsible for the use of any approved retarder in strict accordance with the manufacturer's instructions. Retarders shall not be used together with other admixtures in the same mix unless approved by the Manufacturer.

Preliminary tests of cube strength and the like shall be carried out for all concrete with admixtures. When changing the brand or type of cement and / or retarders and admixtures further tests shall be carried out.

The amount of, and the place for the use of, any admixture and the timing thereof shall be as directed or agreed with the Engineer.

4E.27 CURING:

Freshly placed concrete shall be protected from moisture loss, rain, dust storm, chemical attack, and the harmful affects of heat, wind flowing water, vibrations, shocks, etc.. This protection shall continue until the concrete is sufficiently set such that it is no longer damaged by these factors. The Engineer shall determine when the protection is no longer required, but in any case this shall not be less than 24 hours after the time of placing.

Concrete shall be cured for at least seven days or as required by the Engineer. Curing shall be effected by the direct application of water to the surface of the concrete or by other approved curing methods or curing specifications. In case the application of such curing compounds is delayed for any reason, the concrete shall be kept moist until the application is made. Timber formwork covering the concrete shall be moistened with water at frequent intervals to keep it from drying out during the curing period. Metal formwork exposed to the sun must be shaded from its direct rays, painted white or otherwise protected during the curing period.

4E.28 FAIR-FACED FINISH:

All fair-faced concrete shall be free from honey-combing and any defects arising from faulty formwork or other causes. No patching of any kind shall be allowed upon the removal of the forms except with the full knowledge and approval of the Engineer.

4E.29 TESTING:

Prior to commencing concrete works, the Contractor shall make available on Site the following minimum approved equipment kept in good condition at all times:

-Twelve (12) 15 cm. cube moulds.
-Two (2) slump cones.
-Set of BS Sieves or equivalent.
-Two (2) Balances of different ranges.
-Three (3) thermometers.
-Two (2) plastic cylinders.
-One (1) max / min thermometer.
-Speedy moisture measuring device.
-Other accessories as required.

All testing shall be done in the presence of the Engineer or his authorized representative either on Site or in an approved testing laboratory as directed.

The frequency of testing shall be as noted in the Clauses of this Section and whenever required by the Engineer.

The works Test Cubes shall be made as follows for types 'A', 'B' and 'C' concrete, whichever is more frequent:

a) At least once per mixing day.
b) At least once for each individual part of the structure.
c) At least once per 60 cubic meters of concrete.

For concrete type 'D' and Mass concrete the rate shall be once per each 100 cubic meters or fraction thereof.

At least nine cubes shall be made at one time. Three of the nine cubes are to be tested at seven (7) days. The remaining three cubes are to be tested at 28 days, and their average strength must not fall below the minimum strength specified for each type of concrete and the lowest test result shall not be more than 20% below the three cubes. Another three cubes to be kept as spare.

When the result of the seven-day test is not satisfactory, the Contractor may elect to remove and replace the defective concrete without waiting for the 28 days test. If the result of the 28 days test is unsatisfactory, all concreting shall be stopped at the Contractor's expense and shall not proceed further without the written permission of the Engineer.

The Contractor shall then, in accordance with the instructions of the Engineer, remove cores and test portions of the works, under the supervision of the Engineer. Concrete judged by the Engineer to be defective shall be forthwith cut out, removed and replaced by the Contractor at his own expense.

In the event of strengths consistently higher than those specified being obtained, a reduction in the number of tests may be authorized by the Engineer.

Notwithstanding anything contained in this Clause the Engineer may at any time request samples for testing at a Government or independent laboratory.

4E.30 PRECAST CONCRETE:

The moulds for all pre-cast concrete works, shall be to the accurate dimensions and shape specified or as shown on drawing and or sound construction and to Engineer's satisfaction. All moulds shall be cleaned before every casting. The exposed faces shall be trowelled to a smooth finish.

The mix is to be as specified with an addition of 5% of fine aggregate in order to produce smooth finished surfaces. All pre-cast concrete shall be vibrated unless otherwise agreed by the Engineer.

Each of the pre-cast concrete units shall be properly marked and dated in a manner agreed by the Engineer.
The pre-cast concrete shall be properly cured by continuous spraying or immersion in a pond of water for such length of times, will be instructed by the Engineer. Stacking of pre-cast concrete units shall be properly arranged after curing in separate heaps and shall not be done before the final setting of concrete or such length of time as instructed by the Engineer. The units shall be used in the order of their casting.

4E.31 JOINTS:

Expansion Joints:

Shall be formed in the positions indicated and the details shown on the drawings. The expansion joint shall be filled with bitumen impregnated fibre board or with cork or sponge rubber filler according to ASTM D 1752 to its full depth and width. It will be permitted to use the filling as permanent formwork only for the second casting. Where the filler is exposed it shall be cut back for a depth of at least 1 cm. from the chamfered edge, filled and pointed with a resilient liquid polylsulphide polymer sealant or similar approved.

Construction Joints:

Whenever the placing of the concrete is discontinued other than at the exposed faces, this discontinuity shall form a construction joint. Construction joints are to be made only along a horizontal or vertical plane except that in the case of

inclined or curved members they shall be at right angles to the principal axis. Care shall be taken to prevent off-setting of the joint and to ensure water tightness. The joints shall in every way satisfy the requirements of the Engineer, and shall be in accordance with the Drawings, specification and good practice.

Unless otherwise shown on the Drawings, construction joints will not be allowed in the unsupported portions of slabs, beams and beamlike members. At construction joints the laitance film and porous layer of the already set concrete shall be removed and the surface keyed by hacking and then wire-brushed and thoroughly cleaned.

Immediately before pouring the new concrete, the surface of the existing concrete is to be thoroughly wetted but not saturated and a 2.5 cm. thick coating of fresh cement / sand mortar (having the same proportion of cement / sand as the concrete in the mix) applied to the surface. The new concrete is then to be well compacted into the old.
Concreting shall be carried out continuously to construction joints, the position and arrangement of which shall be as indicated on the Drawings or as approved by the Engineer.

After the concrete has hardened so that the header board or form can be removed without damage to the concrete, it shall be removed and the cement paste removed from the surface by washing with water under pressure or by sand blasting to expose clean well-bounded aggregate.

To facilitate the removal of the cement paste, the surface of the header board or form that shall be in contact with the first pour may be thoroughly covered with a retarder. The retarder shall be a ready-to-use liquid compound that delays the setting of surface concrete to facilitate the exposure of the aggregate and shall be approved by the Engineer in advance of the commencement of the work. It shall produce results satisfactory to the Engineer and shall be selected on the basis of the manufacturer's data and recommendations. When a retarder is used, washing with water under pressure shall be used to expose clean, well bounded aggregate.

After the surface has been prepared, the concrete shall be kept saturated with water until the new concrete is placed, or it shall be saturated for a period of 4 hours before placing the new concrete. Immediately prior to the placing of the new concrete, the forms shall be drawn tight against the concrete already in place and the surface shall be covered with a thin coat of 1:2 mortar.

If for any reason, treatment of the concrete while it is still green is not possible,

the joint must be scarified by power driven scrubbling tools to the approval of the Engineer.

Kickers shall be used at all wall and slab junctions unless approved otherwise by the Engineer. Kickers shall be cast monolithic with the floor slab and shall on no account be cast separately after the slab concrete has set.

Water bars / water stops shall be installed as shown on Drawings or as directed by the Engineer so that they are securely held in the correct position while concreting is in progress. The concrete must be fully and properly compacted around the water stops to ensure that no void or porous areas remain. Where reinforcement is present adequate clearances are to be left between this and all water bars to permit proper compaction of the concrete. No holes are to be made through any water bars except where these are provided by the manufacturer for an approved specific purpose.

4E.32 WATERSTOPS:

The water stops shall be fabricated from a plastic compound the basic resin of which shall be polyvinyl chloride (PVC). The compound shall contain additional resins, plasticizers, inhibitors, or other material such that when the material is compounded, it shall meet the requirements of this Specification. No reclaimed P.V.C. shall be used.

All water stops shall be molded or extruded in such a manner that any cross section will be dense, homogenous and free from porosity and other imperfections. The water stops shall be symmetrical in shape. The minimum thickness of water stop shall not be less than 6mm in the middle and 4mm at the end.

The required sizes and weights shall be as shown on plans.

Water stops shall conform to the following physical requirements of BS 2571.

a) **Tensile Strength**:

Tensile strength shall not be less than 2000 Psi and the test shall be in accordance with BS 2782 (ASTM D-412).

b) Ultimate Elongation.

The ultimate elongation shall be not less than 370% when tested in accordance with BS 2782 (ASTM D-412).

c) Tear Resistance.

The tear resistance shall not be less than 250 Lbs. per inch when tested in accordance with ASTM D-624-48 (Dia. B.O.).

d) Deformation Under Heat.

Deformation under heat shall not exceed 55% when tested in accordance with BS 2782.

The centre line of the water stop shall coincide with the centre line of the joint opening.

Splices, where required, shall be made with a flat soldering, iron, dull knife or flat iron heated to the same temperature required for soft soldering. A flame shall not be applied to the water-stop as a source of heat. Prices shall include for all splices and laps.

Water stops shall be fixed in position, be held firmly in their required places and to the true required straight line. **No piercing of the water stop shall be allowed for any purpose**. The two sides of the water stop, prior to a casting, shall be cleaned free of dirt, loose material, and dust (if necessary washed). Great care must be exercised when casting concrete so as to avoid the bending or the twisting of the water stop and to fill in all spaces under, over, or around the water stop. The type of water stop is to be approved by the Engineer.

4E.33 DRIP-NOSING

Drip-nosing to be of wrought formwork, 2 cm. semi-circular type, to be fixed to all canopies, roofs, undersides of window sills, and other over-hanging and cantilevered concrete work and as directed by the Engineer. All drip-nosing to be fixed true to lines in a workmanlike manner prior to fixing of reinforcement. Square types of drip-nosing shall not be accepted.

4E.34 CHAMFER STRIPS:

Certain visible sharp corners of permanent concrete work, horizontal or vertical, shall be chamfered with wrought chamfer strips 3cm. deep, triangular type supplied and fixed to shuttering internally prior to fixing of reinforcement all as directed by the Engineer on Site.

BRICKLAYER AND MASON

4E.35 CLAY BRICKS

a) General:

The bricks shall be of well burnt clay and shall be hard, uniform in color, sound, square and clean with sharp, well defined edges and shall comply with the following table of sizes.

TABLE (5.1). BRICK SIZES

Dimensions	Size mm	Tolerance + mm
Length	222	3
Width	106	1.5
Depth	67 or 73	1.5

b) Solid Clay Bricks:

Solid clay building bricks shall be of one of the following grades:

Grade I: Intended for external use, use below ground, and where subject to the effects of weather.

Grade II: Intended for use in internal works and above ground level where not subject to the effects of weather.

The bricks shall conform with the physical requirements set out in Table 5.2 below.

c) Hollow Clay Bricks:

Hollow clay building bricks shall be used externally or internally and where the bricks are exposed to the weather and as specified.

Hollow clay bricks shall conform to the physical requirements set out in Table 5.2 below. The design of the cavities and webs, the thickness of the face, shell and of the solid membranes shall be subjected to the Engineer for approval prior to placing the purchase order.

TABLE (5.2). PHYSICAL REQUIREMENTS OF BUILDING BRICKS

Designation	Average Compressive Strength Kg/cm	Average Water Absorption by 5 hr boiling %	Efflorescence
Solid clay Bricks, Grade I	200	17	Nil
Solid clay Bricks, Grade II	100	No limit	Slight
Hollow clay Bricks	150	17	Nil

Sampling and testing of bricks for conformity to dimensions shall be in accordance with BS 3921. ANSI A 41.1 "Building Code Requirement for masonary".

Sampling and testing of bricks for conformity with the physical requirements set out in Table 5.2 shall be in accordance with ASTM C67 "Method of Sampling and Testing Bricks" or BS 3921. The Engineer may at any time require additional tests to be made.

If the bricks tested, fail to comply with the requirements of this specification for the Grade to which the consignment purports to belong, the consignment shall be rejected and removed from site at the contractor's expense.

At least 95 percent of bricks used for facing work shall be free from any transportation and handling defects, such as edge cracking, chipping, and the like.

d) Fire Clay Bricks:
The class and type of the fire clay bricks shall be as required by the Particular Specification.
Fire Clay bricks shall be prepared from well burnt fireclays which are refractory and have a high resistance to spalling, cracking, or failure at high temperatures.

The particular type or class of fireclay bricks specified shall comply with the requirements of ASTM C27, unless otherwise specified in the Particular Specification.

4E.36 SAND-LIME BRICKS

a) General:
The bricks shall be either solid or hollow (cellular) and shall be obtained from the National Industries Co., Sand-Lime Brick Plant in Kuwait.

Sand-lime bricks shall be hard, uniform in color, sound, free from cracks, balls of clay or loam, or visible particles of lime, and shall be clean with sharp well-defined edges, having sizes in accordance with table 5.1, above, or as manufactured by the Sand Lime Brick Plant in Kuwait.

Sand-Lime bricks shall be of either of the following Grades:

Grade I: For use where high strength is required and for construction below the damp proof course.

Grade II: For use in external and internal masonry above the damp proof course.

Hollow Bricks.

For use in construction above the ground level in external or internal walls. Sand-lime bricks shall conform with the physical requirements set out in Table 5.3 below:

Table (5.3). PHYSICAL REQUIREMENTS OF SAND-LIME BRICKS

Designation	Average Wet Compressive Strength kg/cm^2	Average wet Modules of Rupture kg/cm^2	% Shrinkage of Wet length
Grade 1	200	30	0.025
Grade 11	130	20	0.025

b) Sampling and Testing:

Sampling and testing sand-lime bricks for conformity to dimensions shall be in accordance with BS 3921, and for determining conformity with physical requirements shall be in accordance with BS 187, and shall be conducted on the designated lots at the factory. The Engineer may, at any time, require additional tests to be made.

The designated lots from which the samples fail to comply with the requirements of these specifications shall not be used.

c) Handling:

Sand-Lime bricks for interior walling may be tipped at the Site but bricks for facing works shall be unloaded and carefully stacked by hand. At least 95 percent of the bricks used for facing work shall be free from chipping, edge cracking, and the like.

All sand-lime bricks shall be protected during rainy weather with tarpaulins. Any bricks which become saturated shall be allowed to completely dry out before use.

Sand-lime bricks shall not be used in areas exposed to salt water spray e.g. sea spray.

4E.37 SOLID CONCRETE BLOCKS:

Solid concrete blocks shall be hard, durable, solid, clean with sharp well defined edges, and free from any cracks, flaws, or other defects. They shall comply with the following requirements.

TABLE (5.4). REQUIREMENTS FOR SOLID CONCRETE BLOCKS

Dimensions:	Height	20 cm. ± 1%
	Length	40 cm. ± 1%
	Width	as required ± 1%

Compressive Strength at 28 days.
Over gross sectional area:

a) for bearing walls : 60 Kg/Sq.cm. average of 12 blocks.
50 Kg/Sq.cm. minimum for any one block.

b) for non-bearing walls: 30 Kg/sq.cm. average of 12 blocks.
25 Kg/sq.cm. minimum for any one block.

Water Absorption: Percent of dry weight:
a) for bearing walls: 14 or less.
b) for non-bearing walls: 20 or less.

Sampling and testing for the requirements of Table 5.4 above shall in accordance with ASTM C 140 "Methods of Sampling and Testing Concrete Masonry Units", and whenever required by the Engineer.

The Engineer may request and approve a change in the dimensions of the blocks.

The cement, fine aggregate and water used in the manufacture of the solid concrete blocks shall be as specified in Concrete Section. The fine aggregate shall comply with the grading of Table 2. Grading zone 1, BS 882. When colored cement is required, it shall be Type 1 portland cement as in concretor section, with a lime proof, non-fading, color pigment complying with BS 1014, samples of the colored concrete blocks shall be prepared and submitted to the Engineer for approval, and all colored concrete blocks used in the works shall be of the same hue and intensity as the reference samples.

The blocks shall be made from a mix of 250 Kg. of cement to 1500 Kg. of fine aggregate. If for any reason the strength requirement is not achieved, the cement shall be increased at the Contractor's expense. The water used in the mix shall be of a sufficient quantity to allow complete hydration of the cement without providing an excess when moulding.

The blocks shall be either obtained from approved local factories or manufactured

on Site, the blocks shall be press moulded in approved moulds and vibrated with a pressure machine having a minimum of 2800 cycles per minute. Immediately after moulding the blocks shall be placed on a clean, and level, area for the inspection and approval of the Engineer.

The blocks manufactured on Site shall be cured in the shade by being kept thoroughly moist with water applied with sprinklers or other approved means for a period of at least seven days. Blocks shall be stacked on a clean and level platform free from earth or sand during the curing process.

Blocks shall be stacked in a honey comb fashion after curing; solid stacking shall not be permitted, blocks shall not be used prior to one month after the date of manufacture.

4E.38 HOLLOW CONCRETE BLOCKS FOR WALLS:

Hollow concrete blocks shall be the same as for solid concrete Blocks above and as follows:

The design of the cavities and webs shall be submitted to the Engineer for approval prior to manufacture.

The thickness of the face, shell and of the membrane of solid portions shall be no where less than 4 cm. the combined thickness of the solid portions shall be more than one third of the width and length of the block respectively.

The nominal width of hollow blocks shall be 10, 12, 15, 20, 25, 30, or 40 cm. as shown on the Drawings required by the Particular Specification or as directed by the Engineer.

4E.39 HOLLOW CONCRETE BLOCKS FOR ROOFS:

Hollow concrete roof blocks shall be the same for solid concrete blocks above, except as follows:

The design of the cavities and webs shall be submitted to the Engineer for approval prior to manufacture. The minimum thickness of the perimetric shell of solid portions of the membranes shall not be less than 4 cm. The section across the cavities and webs shall be trapezoidal.

The dimensions and weight shall be in accordance with table 5.5 below. The tolerances on dimensions shall be $\pm$ 1%.

TABLE (5.5). DIMENSIONS AND WEIGHTS OF HOLLOW CONCRETE ROOF BLOCKS

Bottom Width (cm)	42	42	42	42	42	35	37	37
Top Width (cm)	38	38	38	38	38	31	35	35
Length (cm)	20	20	20	20	20	20	20	20
Depth (cm)	12	14	18	20	22	24	30	34
Block weight (kg) ± 5%	10	12	14	15	16	1	18	20

4E.40 MORTARS:

a) Materials.

1. Ordinary Mortar.

The cement, fine aggregate or sand, and water used in ordinary mortars shall comply with the respective requirements of the Concrete Section of this specification. The grading of the sand shall be in accordance with either grading zone 3 or Grading zone 4, Table 2 BS 882.
Imported hydrated lime shall comply to Class B, part I of BS 890.

2. Fireclay Brick Mortar.

The cement used shall be an approved fire cement obtained from an approved manufacturer to resist contraction under heat. The fine aggregates shall be either clean sand complying with the requirements of fine aggregates of the Concretor Section, or burnt fireclay made by crushing ordinary firebricks. The water shall be clean, potable water.

Kuwait quicklime, shall be obtained from the National Industries Co. Sand-Lime brick plant and shall be completely hydrated by the Contractor in accordance with the requirements of the Plaster Section, and approved by the Engineer entirely responsible for complying with the requirements of the National Industries Co., in respect of the purchase and supply of lime.

Plasticizers for mortars shall be of an approved manufacture and shall be used in strict accordance with the manufacturer's instructions.

Pigment for coloring mortars shall comply with BS 1014.

Samples of all materials to be used in the mortar shall be submitted to the Engineer for testing and approval prior to its use in the Works.

b) Mix Proportions.

The mix proportions and their intended use for ordinary mortars are given in

Table 5.6 below. These mix proportions shall be strictly adhered to.

TABLE (5.6). MIX PROPORTIONS FOR ORDINARY MORTARS

Nominal Mix	Cement Kg.	Fine aggregate m3	Kuwait Lime (Saturated Hydrate) m3	Imported Lime (Dry Hydrate) kg.	Intended Use
1:6 With Plasticizer	250	1.00	-	-	Building mortar, Block work and Clay Brickwork.
1:4 Without Plasticizer	350	1.00	-	-	Building & pointing mortar Block work Brickwork.
1:3 With Plasticizer	500	1.00	-	-	Pointing mortar and Clay Brickwork.
1:4 dry lime with 10% cement	150	1.00	-	160	Building & pointing mortar for sand lime bricks.
1:3 Kuwait lime with 10% cement	150	1.00	0.33	-	ditto- when lime of Kuwait is used.

Mix proportions for fire-clay brick mortars shall be one part of cement to 2 parts of fine aggregate.

c) Mixing:

The mortar shall be thoroughly mixed dry until a uniform mix is obtained. Sufficient water shall then be added and the mixing continued until a homogeneous mix is obtained. Excess water shall not be present in the mix. In the case of Kuwait Line, the cement and sand shall be mixed first and the lime added with the water. The mix shall in every way satisfy the Engineer.

Mortar shall be mixed in an approved location and care shall be taken that no foreign matter enters the mix, or a loss of liquid occurs during mixing.

Mortar shall be used in the Works as soon as possible after mixing but in no case after the initial set commences. In no event shall mortar be remixed and used after the initial set has taken place.

4E.41 WORKMANSHIP:

a) General:

The Contractor shall provide all labour, materials, plant, scaffolding, coverings and anything else necessary for building the block work and brickwork. The

Contractor shall execute and make good all necessary chases, holes, mortices, rebates and the like, build-in lintels, timber, etc., as required and perform all necessary attendance upon other trades and make good on completion. The Contractor shall be responsible for covering and protecting the fair faced brickwork during the progress of the Works and shall clean the whole upon completion, make good, point, and leave all perfect and to the satisfaction of the Engineer.

All block work and brickwork shall be set-out and built to the dimensions and type of bond shown on the Drawings or required by the Particular Specification.

b) Walls:

All burnt clay bricks or concrete block shall be soaked with water before being used. Walls left unfinished shall be wetted before work is recommenced. Sand-lime bricks shall only be wetted sufficiently to prevent excessive absorption. The faces of walls shall be kept clean and free from mortar droppings and splashes, and the like.

Walls shall be carried up regularly without leaving any part more than one meter lower than another unless the permission of the Engineer is first obtained. Work which is left at different levels shall be raked back. In the case of cavity walls, both thicknesses shall be carried up together and in no case shall one thickness be carried up more than 40 cm. in advance of the other.

The courses of brickwork of block work shall be laid and jointed in the appropriate mortar with perfectly level horizontal joints. Each course shall be well flushed with mortar throughout its full length and width. The vertical joints shall be properly lined and quoins, jambs, and other angles plumbed, as the work proceeds. All walls shall be plumbed vertical.

Sand-lime bricks shall generally be laid with the frog or depression for mortar upwards, except where used in the top course of a wall which is not protected by a coping, where they shall be laid with the frogs downwards.

The height of ten courses shall be 75 cm. for clay-bricks, 78 cm. for sand-lime bricks and 210 cm. for concrete blocks.

Broken bricks or blocks shall not be used except where required for bond.

Walls which are to be left un plastered shall have a fair-face consisting of selected bricks or blocks pointed with a neat weathered or flush joint upon completion, or as directed by the Engineer.

Where required the exposed face of brickwork built in clay brick shall be rubbed down to show a smooth face and sharp square edges.

Walls which are to be plastered shall have the horizontal joints raked out to depth of 1.1/2 cm. to form a key.

Curtain walls shall be reinforced in each course by means of 6mm diameter horizontal and vertical steel bars.

Cavity walls shall be built to the dimensions shown on the Drawings and the two thicknesses shall be bonded together with wall-ties spaced one meter apart horizontally and approximately 40 cm. apart vertically and staggered. Extra ties shall be provided at reveals, quoins and openings.

The ties shall be of the butterfly twist type 3.2 mm mild steel wire, zinc coated to comply with BS 1243. The length of the ties shall be approximately 8 cm. less than the total thickness of the wall.

The cavity shall be kept clear by lifting screeds or other means approved by the Engineer and shall be left clean at completion.

All brick and block walls shall be bonded to columns by means of wall ties complying with BS 1243 which are previously cast in the concrete. The ties shall be 20 cm. long with 8-12 cm. imbedded into the wall at the rate of one tie each two courses for block-work, and one tie each five courses of brickwork.

Allowance shall be made for leaving, temporarily, open courses immediately under all structural members built into the walls. These open courses shall be left in suitable positions to permit the structural members to take up their full deflection. The open courses shall be made good and pointed after the structural members have been fully loaded and before the completion of the Works.

Walls shall be properly cured by sprinkling with water for a period not less than 3 days after completion.

c) Roofs:

Hollow concrete roof blocks shall be set out on the formwork to the dimensions shown on the drawings. They shall be lined in even rows true to a horizontal line, and the spacing between rows shall be uniform and equal.

Broken blocks shall not be used, except where a whole block is clean broken to complete the required lengths of a row. The Engineer shall inspect and approve

the hollow concrete blocks before any further work is carried out. The blocks shall be thoroughly wetted with water prior to placing the concrete.

d) Miscellaneous:
Arches shall be constructed in solid concrete blocks with radial joints and as appropriate to the sizes shown on Drawings. The Contractor shall provide and erect temporary centering of timber construction and ease, strike and remove on completion.

The Contractor shall cut and fit brickwork or block work around steelwork, etc., leave or form chases for edges of concrete slabs, staircases, ends of partitions etc., cut chases for pipes, conduits etc., and make good.

The Contractor shall build all overlaying courses, corbel, copings, etc., where shown on the Drawings and build in or cut and pin ends of sills, steps, lintels, etc., as required.

Wooden plates and door and window frames shall be added and exposed edges pointed in mortar and fixing cramps shall be built in.

Metal windows shall be bedded in mortar and exposed edges pointed in mastic. Fixing lugs shall be built in and channels in frames grouted with mortar.

The Contractor shall construct or build in fire places, build in fire brick linings set in fireclay, and construct flues where shown on the drawings.

Expansion joints as shown on Drawings or as directed in the Particular Specification shall be constructed generally as either:

1) Open expansion joint with a clean straight cavity of the width directed.
Or
2) Joint filled with an impregnated fibre board of the thickness directed.

4E.42 DAMP-PROOF COURSES:

Damp-proof course to walls shall consist of one layer of bitumen felt as in the Roof Section of this Specification, bonded with 60/70 penetration bitumen or as shown on the Drawings. The damp-proof course shall be well lapped at corners and joints and bedded in cement mortar (1:4) mix and pointed both sides.

In the case of faced brickwork the damp-proof course shall be kept 1 cm. back from the face of the wall and the pointing to that edge of the damp-proof course shall be executed three months after completion of the wall.

Where shown on Drawings, or directed by the Engineer, the Contractor shall similarly provide and build in a vertical damp proof course at jambs of openings in cavity walls and a horizontal dampproof course above such openings and to parapet walls.

PLASTERER

4E.43 GENERAL:

The Contractor shall provide all labour, materials, scaffolding, coverings, equipment, tools, anything else necessary to carry out, protect, and maintain the Works.

He shall make good any defects to the satisfaction of the Engineer and shall clear away and clean up any splashes, drippings, etc., upon completion.

4E.44 MATERIALS:

a) The cement, sand, and water used for plastering shall comply with the requirements of the Concrete Section.

   The sand for plastering shall be clean and shall be washed in potable water if necessary. The sand shall be sieved and graded to meet the following requirements:

   i) For plaster undercoats, the grading shall be as in BS 882 Table 2, Grading Zone 2.

   ii) For plaster finish coats, the grading shall be as in BS 882 Table 2, Grading Zone 3 or Grading Zone 4.

b) Gypsum plaster shall be a dual-purpose plaster (undercoat and finishing) of the Retarded semi hydrate Gypsum Class Type C, Class B, of BS 1191 The resultant plaster shall be capable of being trowelled to a smooth surface, shall be highly resistant to cracking and crazing and shall be chemically inert when set.

c) Imported lime shall be of the hydrated type complying with Class B of BS 890.

d) Kuwait lime shall be obtained from the National Industries Co. Sand-Lime Brick plant, as directed in the Bricklayer Section. The Kuwait lime may be supplied in the form of quicklime. In this case it must be completely hydrated before use in accordance with the following procedure.

   i) <u>Hydration of Small Quantities</u>:
   The quick lime should be placed in a drum or barrel containing at least twice

as much water, by weight, as quicklime. This mixture should be stirred thoroughly and then left to slake for not less than 24 hours, when it will become a saturated hydrate of lime (known as lime putty) with free water covering for a few days depending upon the prevailing climatic conditions.

ii) Hydration of Large Quantities:
The quicklime should be placed into a drum or barrel containing at least twice as much water, and then left to slake for not less than one hour. After this time the resultant hydrate should be passed through a sieve into a storage pit where it should remain with free water on the top for at least 24 hours before use.

The vessels for hydrating, carrying, or measuring the lime shall be clean sound drums, tanks, or buckets. The sieves shall not be coarser than 2 mm mesh. The storage pit for the lime may be constructed in the ground and lined with boards and shall be fitted with cover battens to prevent loss of liquid or entry of earth etc.. The pit shall be properly fenced or covered with timber boarding to prevent danger to workmen or other persons.

The slaked saturated hydrate shall be freed from excess water prior to its use in plaster mixes.

e) Color additives and other admixtures where required shall be used in accordance with the manufacturer's instructions.

4E.45 MIXING:

a)The plaster mix proportions shall be those required by the Particular Specification or as shown on the Drawings and selected from Table 6.1 below.

TABLE (6.1). MIX PROPORTIONS OF PLASTERS

Nominal Mix	Cement Kg.	Sand m3	Kuwait Lime Saturate Hydrate m3	Imported Lime (Dry Hydrate) Kg.
1:1 Cement:Sand.	1450	1.00	-	-
1:4 Cement:Sand.	350	1.00	-	-
1:5 Cement:Sand with Plasticizer.	300	1.00	-	-
1:5 Cement:Sand with 20% imported Lime.	300	1.00	-	125
1:3 Cement:Sand with 10% Kuwait Lime.	500	1.00	0.100	-
1:4 Imported Lime-Sand graged with 10% Cement.	150	1.00	-	160
Kuwait Lime-Sand graded with 10% cement.	150	1.00	0.333	-

Allowance has been made in this Table for the sand contained in the Kuwait Lime.

b) Mixing of cement-sand mortars, whether by hand or by approved machine shall be as stated above. When a plasticizer is used, the manufacturer's instructions shall be strictly adhered to and followed.

c) With regard to the lime mortars gauged with cement, the addition, just before use, of the cement to small quantities of the lime/sand mix shall preferably stake place in a mechanical mixer and mixing shall continue for such time as will ensure uniform distribution of materials and uniform color and consistency. It is important to note that the quantity of water used shall be carefully controlled.

d) Gypsum plaster shall be mixed in a clean pail or other approved vessel. The required amount of water shall be placed in the pail and the plaster added gradually and allowed to soak for 5 minutes. It shall then be stirred to a uniform consistency free from lumps and no more material shall be mixed than can be used in half an hour, unless an approved retarder has been used.

4E.46 WORKMANSHIP:

a) General:

All plastering shall be executed in a neat workmanlike manner. All faces except circular work shall be true and flat, angles shall be straight and level or plumb.

Plastering shall be neatly made good up to metal or wood frames and skirting and around pipes or fittings and the like Angles shall be rounded to 5mm radius.

Surfaces of undercoats shall be well scratched to provide a key for finishing coats. Screed marks or making good on undercoats shall not show through the finishing coats.

Surfaces described as floated shall be finished with a wood or felt float to a smooth flat surface free from trowel marks.

Surfaces described as trowelled smooth shall be finished with a steel or celluloid trowel to a flat surface free from trowel marks.

All tools, implements, vessels and surfaces shall at all times be kept scrupulously clean and strict precautions shall be taken to prevent the plaster or other materials from being contaminated by pieces of partially set material which would tend to retard or accelerate the setting time.

b) Preparation:

All surfaces to be plastered shall be clean and free from dust, grease, loose mortar, and all traces of salts. Where cement plaster is to be applied the surfaces shall first be dashed with a mixture of port land cement and sand (1:1 mix) to form a key.

All surfaces shall be thoroughly sprayed with potable water and all free water allowed to disappear before plaster is applied.

Before plastering is commenced all junctions between differing materials shall be reinforced. This shall apply where walls join columns, where brick walls join block walls and similar situations where cracks are likely to develop and as directed by the Engineer. The reinforcement shall consist of a strip of approved wire mesh (10 to 15 mm Hexagonal mesh) 15 cm. wide, or of an approved expanded metal with galvanized nails and washers, galvanized staples or similar.

The reinforcing mesh shall be fixed at both edges by stapling, plugging, or nailing at intervals not exceeding 50 cm. and as required. The reinforcement shall be fixed so that it is embedded completely in the undercoat of plaster.

c) Curing:
Cement plasters shall be kept moist by sprinkling with water at regular intervals for a period of at least three days and until no powdery particles are present to the satisfaction of the Engineer.

Gypsum plasters do not require curing.

d) Application:
After preparing the surface as paragraph (b) above the undercoat shall be applied to the required thickness between screeds laid, ruled and plumbed as necessary. When nearly set, the surface of the undercoat shall be scratched as in paragraph (a) above. The undercoat shall be allowed to set completely and shall be cured as described in (c) above before the finish coat is applied. Where plastering is applied in one coat or where rough cast is to be applied the scratching should be omitted.

The finishing coat shall be applied to the required thickness by means of a laying on trowel and finished to give the required surface.

Sprayed finish shall be applied with an approved machine to give a finish of even texture and thickness. The sprayed finish shall be applied in four separate coats allowing time for drying between coats. Application in one continuous operation to build up thick layers shall not be permitted. The total finished

thickness of the four sprayed coats shall be not less than 3mm. The sprayed finish shall not be applied until all repairs and making good to the undercoat are completed. Rainwater pipes, fittings and the like shall first be fitted, then removed during the spraying process and refitted and jointed afterwards. Any plaster which adheres to pipes, doors, window sets, and the like, shall be immediately cleaned away. Curing as in paragraph (c) above shall take place after the application of the fourth coat.

4E.47 USES OF PLASTER:

The type, mix and thickness of plaster for each location shall be as required in the Particular Specification or as shown on the drawings, and shall generally be selected from the schedule of plasters given below. Any plastering more than 15 mm in thickness shall be applied in two coats.

TABLE (6.2). PLASTER SCHEDULE UNDERCOAT

Description	Thick mm		Mix	Surface	Remarks
	Wall	Ceil			
Cement & Sand.	10	10	1:4	Floated	Render and spray for Extl. Use.
Cement & Sand.	10	7	1:4	Scratched	Render and set for Intl. Use.
Cement & Sand.	as	Reqd	1:4	Scratched	Plain Face for Extl. & Intl. Use May be applied in one coat (See Note).
GAUGED PLASTER Cement & Sand + Kuwait Lime.	as	Reqd	3:9:1	Scratched	Ditto
Imported Lime plus Sand + Ct.	as	Reqd	1:10:2.5	Scratched	Ditto
Kuwait Lime & Sand & Cement.	as	Reqd	1:9:3	Scratched	Ditto

TABLE (6.3). FINISHING COAT

Description	Thick mm		Mix	Surface	Remarks
	Wall	Ceil			
Cement & Sand.	3	3	1:1	Sprayed	Render and spray for External. use.
Gypsum.	as	Reqd	-	Trowelled	Render and set for Intl. use.
Cement & Sand.	as	Reqd	1:4	Trowelled / Floated	Plain Face or Extl. & Intl. use May be applied in one coat (See Note).
GAUGED PLASTER Cement & Sand + Kuwait Lime.	as	Reqd	3:9:1	Trowelled / Floated	Ditto
Imported Lime & Sand with Cement.	as	Reqd	1:10:2.5	Trowelled / Floated	Ditto
Kuwait Lime & Sand + Cement.	as	Reqd	1:9:3	Trowelled / Floated	Ditto

NOTE:- One coat to ceilings, only if finished thickness is 12 mm and the required surface finish is obtained.

4E.48 GLASS BRICKS:

Glass bricks shall be used in positions shown on the drawings, the type to be used will be P.B.32 size 20cm. x 20cm. x l0cm. weight 6.1/2 lbs. Every course is to be reinforced with expanded metal strips carried into the brickwork / blockwork.

The mortar to be used is to be one (1) part white cement one (1) part hydrated lime and four (4) parts sand by volume. The mix must be fairly dry and fatty, and the sand must be clean and free from gravel and silt. The pointing is to be carried out by raking the joint back slightly as the work proceeds.

Clearance joints of 1/2" are to be provided at the top and sides of all panels. These are to be filled with fibre glass and pointed with a non-hardening compound.

PAVIOR, MARBLE AND TERRAZZO WORKER.

4E.49 GENERAL:

The Contractor shall provide all materials, labour, equipment, tools, coverings, and incidentals to carry out, protect, make good, and maintain the works to the satisfaction of the Engineer. The Contractor shall protect all pavings from damage during subsequent operations, shall clear away upon completion, polish and clean throughout and leave all work in a perfect condition to the satisfaction of the

Engineer.

4E.50 MATERIALS:

a) Cement, Aggregate, Water.
Portland cement, fine aggregate and water shall be as previously specified in Section 4, concretor. The fine aggregate shall be to grading zones 2 or 3, Table 2, BS 882.

b) Color Pigments:
Color pigments shall be lime proof and non-fading and to BS 1014.

c) Marble Chippings:
Marble chippings shall be of an approved quality in irregular pieces. The pieces should preferably be roughly cubical in shape. Flaky pieces shall not be used. Sizes shall be as required by the Engineer and as selected from Table 7.1 below.

d) Granite Chippings.
Granite chippings shall be to BS 1201 graded as in Table 7.1 below.

TABLE (7.1). GRADING OF GRANITE AND MARBLE CHIPPINGS

Sizes			Percentage Passing by Weight.	
BS. Sieve No.	Approximate mm.	Inches	Granite Chippings	Marble Chippings
-	13	1/2	100	-
-	10	3/8	95 to 100	95 to 100
-	5	3/16	30 to 60	25 to 60
7	2.4	.095	20 to 50	5 to 30
14	1.2	.047	15 to 40	0 to 10
25	.6	.024	10 to 30	-
52	.3	.012	5 to 15	-
100	.15	.006	0 to 5	-

It is essential that closer grading limits be selected for the Marble Chippings if a consistent and uniform surface texture is desired.

e) Glazed Ceramic Wall Tiles:
Glazed ceramic tiles (porcelain) for walls shall be either white or colored, true to shape, flat, free from flaws, cracks and crazing, uniform in color, keyed on the back and shall comply with BS 6431 shall be 15 cm. x 15 cm. x 6 mms thick and of the color selected by the Engineer unless otherwise required by the Particular Specification or shown on the Drawings.

f) Glass Mosaic Tiles:

Glass mosaic tiles shall be approved first class, formed from a homogeneous vitreous paste having a high silica content, and having a uniformly opaque color throughout their thickness. They shall be fixed with soluble adhesive to strong fixing paper in sheets 30cm. x 30cm. and then packed in strong cardboard cartons wrapped in bituminous paper. The cartons shall be packed 2 for shipment in a wooden case containing about 3m of tiles, to facilitate handling. "Owls beaks" tiles for edging shall be the same as the glass mosaic except that the fixing sheets shall be one tile wide.

The glass mosaic tiles shall be 20mm x 20mm x 5mm thick with a dimensional tolerance of ± 1% and shall weigh about 10 Kg/m have flat faces, the rear edges chamfered and the color and surface as shown on the Drawings or as required by the Particular Specification.

g) Ceramic Floor Tiles:

Ceramic floor tiles shall be true to shape, flat free from flaws, cracks, uniform in color and of an approved type, make and color. Dimensions and tolerances shall comply with BS 6431, and as called for in the Particular Specification or as shown on the Drawings.

h) Terrazzo Tiles:

Terrazzo tiles shall be true to shape flat, free from flaws, cracks and pittings, of smooth surface and of an approved type, make, color and texture. They shall consist of a facing of cement, with or without pigment added, or colored cement. The facing shall be wear resistant and of a finished thickness not less than 5mm. Backing shall consist of ordinary Portland cement and sand (1:5 nominal mix).

All terrazzo tiles shall be supplied polished.

Terrazzo tiles shall be cured by total immersion, after initial set, in clean potable water for at least 24 hours before grinding, filling and polishing.

Terrazzo skirting 10 to 20 cm. high shall be produced in the same manner as for tiles but with chamfered or squared top edges as shown on the Drawings.

Tiles shall be square with clean edges and of the sizes and dimensions shown in Table 7.2 below as required by the Particular Specification or shown on the Drawings.

TABLE (7.2). TERRAZZO TILE DIMENSIONS

Size cm.	Size Tolerances mm	Minimum Total Thickness mm
20 x 20	± 0.5	20
25 x 25	± 0.5	25
30 x 30	± 1.0	25
40 x 40	± 1.0	30

i) Pre cast Terrazzo Units:
Terrazzo treads to stairs, sills, doorsteps, and any other pre cast terrazzo elements bigger than 40 cm. x 40 cm. shall be reinforced with 6 mm diameter steel bars in a square mesh 15 cm. x 15 cm.

j) Marble:
Marble flooring shall be a minimum of 30mm thick. Marble linings or facings to walls, wall skirting and risers to stairs shall be a minimum of 20 mm thick. Treads to stairs shall be a minimum of 35 mm thick. Window sills shall be a minimum of 40 mm thick. Marble shall be cut square and true and shall be uniform in shape and thickness. Sizes, types, patterns, and finishes shall be as required in the Particular Specification or as shown on the Drawings.

k) Cement and Sand Tiles:
Cement and sand tiles shall be true to shape and size, free from flaws, cracks and pitting and of an approved type and make. They shall consist of a facing of cement with or without pigment added and sand (1:2.5 nominal mix). The facing shall be wear resistant and of a finished thickness not less than 7.5mm. Backing shall consist of ordinary port land cement and sand (1:5 nominal mix).

Curing shall be by total immersion, after initial set, in clean potable water for at-least 24 hours.

Tiles shall be square with clean edges and of the sizes, dimensions and design required by the Particular Specification or as shown on the Drawings. Sizes and tolerances in dimensions shall be as in Table 7.3 below.

TABLE (7.3). CEMENT AND TILE DIMENSIONS

Size cm.	Size Tolerances mm	minimum Total Thickness mm
20 x 20	± 0.5	20
25 x 25	± 0.5	25
30 x 30	± 1.0	25
40 x 40	± 1.0	30

1) P.V.C.Tiles:
Such tiles when used shall be as specified in the Particular Specification and shall be supplied from an approved manufacturer. Laying of these tiles shall conform in all respects to the manufacturer's specifications.

4E.51 MIXING AND PROPORTIONS:

Fine aggregates and chippings for in-situ pavings and locally manufactured tiles shall be measured separately in approved gauge boxes on clean, dry, and level surfaces. The cement shall be measured in one bag (50 Kg.) units and the water by volume.

Materials shall be mixed mechanically as previously specified in the Concrete Section.
The following Mixing Table 7.4 shall be strictly adhered to in all cases. Variations will be permitted only when demanded by the Particular Specification for individual works or with the prior written consent of the Engineer.

TABLE (7.4). Mixing Table.

Nominal Mix	Cement kg,	Fine Aggregate m^3
1 : 1	1450	1.00
1 : 2	750	1.00
1 : 2.5	600	1.00
1 : 3	500	1.00
1 : 4	350	1.00
1 : 5	300	1.00

4E.52 PRECAST CONCRETE PAVING SLABS:

Pre cast concrete slabs may be obtained from the Kuwait National Concrete Factory or may be manufactured on Site.

Pre cast paving slabs manufactured on Site shall generally be executed in grey or colored Type 'B' concrete, and shall be properly vibrated by means of surface vibrators.

Pre cast paving slabs shall be reinforced with 6mm diameter steel bars in a 15cm. x 15cm. square mesh. Unless otherwise specified, the sizes of these slabs shall comply with the following:

Size (cm.)	Minimum Total Thickness (mm).
40 x 40	50
60 x 40	60
80 x 40	70

100 x 40 80

Pre cast concrete slabs shall be properly cured for a period of at least seven days by being kept thoroughly moist with water or by other approved means.

4E.53 IN-SITU PAVINGS:

a) Granolithic Pavings:
These shall consist of Portland cement and granite aggregate (1:2:5 nominal mix) mixed with sufficient water to give a plasticity suitable for laying. If these pavings are laid on a matured concrete sub-base, the concrete shall first be well cleaned, wetted and brushed with a port land cement grout.
To produce a wearing surface the granolithic mixture shall be tamped with a wood float and trowelled twice with a steel trowel to produce a smooth finish. The paving shall be laid in alternate bays not exceeding 9 m in area and the bays shall be separated by expansion strips of brass or other approved material.

Granolithic paving shall be cured as called for in the Concrete Section.

The thickness shall be as required by the Particular Specification or as shown on the Drawings but not less than 20 mm.

b) Cement and Sand Pavings:
These shall consist of Portland cement and sand (1:3 nominal mix) mixed with sufficient water to give a plasticity suitable for laying. If laid on a matured concrete sub-base, the same precautions should be taken as described for granolithic pavings above. The pavings shall be laid in bays described above for granolithic pavings.

Cement and sand pavings intended as a wearing surface shall be trowelled twice with a steel trowel to produce a smooth finish.

Cement-sand pavings shall be cured as called for in the Concrete Section.

The thickness shall be as required by the Particular Specification shown on the Drawings but not less than 25 mm.

c) Terrazzo Pavings:
These shall consist of white or colored cement and marble or granite chippings (1:3 nominal mix) mixed with sufficient water to give a plasticity suitable for laying. The finished thickness shall be not less than 12 mm for pavings and 5mm for wall facings and skirting.

Terrazzo pavings shall be laid immediately following a screed of cement and sand (1:5 nominal mix) at least 15 mm thick. This screed shall be applied following the concrete sub-base. If the screed is laid on a matured concrete sub-base, the concrete shall first be well cleaned, wetted and brushed with a Portland Cement Grout.

The terrazzo Saving shall be laid in bays not exceeding 9 m^2 in area and the bays shall be separated by expansion strips of brass or / other approved material truly level with the finished surface.

Terrazzo pavings shall be rubbed down to a grit finished surface free from blemishes after the initial set, and cured by covering them with waterproof paper or wetted hessian for a period of at least three (3) days.

After curing, the pavings shall be filled with a cement grout of the same color and polished by approved machine using carborendum abrasive (No. 140) and potable water until an even and smooth surface is obtained to the satisfaction of the Engineer.

Wall facings and skirting shall be treated as for pavings except that they may be applied to a sand-cement plaster undercoat instead of sand cement screed. If the plaster undercoat is matured then it shall be treated as for matured concrete prior to application of facings or skirting.

4E.54 LAYING OF TILES:

a) Wall Tiles:

A screed shall be laid for wall tiling which shall be cement and sand (1:4 nominal mix), at least 10 mm thick. The materials, methods of mixing, preparing and applying the screed shall be similar to those described for cement-sand plaster undercoat. The surface shall be scratched in an approved manner, when nearly set, to form a key. The surface of the screed shall be well wetted before the tiling is applied.

All tiles shall be immersed in clean potable water for 24 hours or until saturated and all surplus water drained off before bedding.

Tiles shall be bedded in cement and sand mortar (1:4 mix) 6mm thick to a true vertical face with continuous horizontal and vertical joints and pointed in neat white or colored cement and any surplus which adheres to the face of the tile shall be wiped off with a damp cloth before it sets hard.

The external angles, sides and top edges of glazed wall tiling shall be formed

with rounded edge (bull nose) tiles. At intersections returned rounded edge tiles shall be used.

The joints shall be either closed, tight joints or open joints not exceeding 2mm wide. Joints shall match those of the floor tiling and special approved fittings shall be used at the intersections between wall tiles and horizontal surfaces.

Where tiling abuts against wood or metal frames or other tiling at angles and around pipes etc., it shall be carefully cut and fitted to form a close neat joint. Open irregular joints filled with cement and sand or plaster will not be permitted.

b) Glass Mosaic Tiles:

Glass mosaic tiles shall be applied as follows:

First a key coat shall be applied followed by a base coat, then a bedding coat in which the mosaic tiles shall be set.

The key coat shall consist of cement and sand (1:5 mix) at least 5mm thick which shall be applied four or five days before the mosaic. All irregularities of the wall surface shall first be leveled off. Application to walls etc., shall generally commence from the bottom working upwards by means of throwing the mix vigorously against the surface with a casting trowel and pressing it firmly into joints etc., to ensure adhesion. The surface shall be finished plumb and straight, and shall be scratched in an approved manner, when nearly set, to form a key. The key coat shall be well wetted before the base coat is applied.

The base coat shall consist of cement and sand mortar (1:5 mix) with a proportion of imported hydrated lime of up to 20% by volume added to delay setting.

The base coat shall be applied with the aid of vertical screeds which shall be fixed at the edges of key coat surfaces and in between as required to permit accurate application. Screeds shall consist of timber strips 5mm to 8mm thick x 20 mm wide. The strips shall be coated with base coat mortar, firmly set to the wall and carefully plumbed on face and edge. The base coat shall be applied and carefully leveled between the screeds to give a smooth flat surface which shall be kept moist until the mosaic is fixed. The screeds shall be removed and the base coat leveled up.

The bedding coat shall consist of neat white cement and water mixed as previously described for gypsum plaster, see Plaster Section. The bedding coat shall be applied to a thickness of l mm immediately before the mosaic is fixed.

Horizontal and vertical reference lines shall be drawn on the bedding coat to ensure accurate fixing of the mosaic.

The mosaic sheets shall have their backs coated with a layer of bedding coat mortar which shall be well trowelled in over the whole sheet so that all spaces between tiles are completely filled.

The prepared sheets of mosaic tiles shall then be fixed true to level and plumb commencing from the bottom working upwards. Each sheet shall be patted with a steel float especially along the joints between sheets. Any dropped tiles shall be replaced. The surfaces shall be hammered lightly over a tapered wood block especially where the fixing paper has a dry appearance indicating insufficient penetration of bedding mortar. It is essential that the finished surface be flat and true and that the top edge be leveled.

The entire surface shall then be sprayed three or four times with water to soften the glue on the fixing paper. In cases where the mosaic is exposed to sun or wind the spraying shall be substituted by brushing with a coat of grout similar to the base coat mortar. When the fitting paper is thoroughly wet, it shall be carefully peeled off keeping the hand close to the surface to prevent dislodging the tiles.

The Contractor shall then carry out any adjustments to tiles which are necessary to render the joints between sheets undetectable.

The surface of the mosaic shall then be sprayed with water and all traces of glue and excess mortar shall be washed off. The surfaces shall then be wiped dry with clean wood shavings. The joints shall then be grouted using bedding mortar applied by means of a small trowel to ensure that all joints are completely filled for their full depth. Surplus mortar shall be wiped off with wood shavings.

The special edge tiles ('Owls' beaks) shall then be applied, leveled and grouted.

The entire surface shall then be grouted once more and cleaned off with wood shavings.

After two to six days, at the discretion of the Engineer, the surface shall be washed with a 25% solution of hydrochloric acid applied by brush. The surface shall then be sprayed several times with clean water and dried off with clean white rags.

c) Ceramic Floor Tiles:
Ceramic floor tiles shall be laid and bedded direct on to concrete sub-floors using a cement and sand screed (1:4 nominal) mix. The thickness of the screed shall be such that the minimum total thickness of tiles and screed together shall be 30 mm.

Tiles shall be laid with square joints and finished to a true flat surface.

Tiling shall be grouted on completion using cement of a color to match the tiles or white cement. All joint shall be filled completely with grout. Any surplus grout shall be immediately cleaned off the face of the tiling and surrounding surfaces.

When the tiling is completely set, the surfaces shall be properly cleaned as directed.

d) Terrazzo Tiles:
Terrazzo tiles shall be laid and bedded direct on to concrete sub-floor using cement and sand screed (1:4 nominal mix). The minimum thickness of the screed shall be 18 mm. The total thickness of cement and sand screed and tiles shall not exceed 50 mm. All tiles shall be laid with square joints and finished to a true flat surface.

All tiling shall be grouted on completion, care being taken to fill all joints completely. The grout shall consist of neat cement of a color to match the tiling or of white cement. Any surplus grout shall be immediately cleaned off the face of the tiling and surrounding surfaces and all tiling shall be carefully cleaned, off.

All terrazzo surfaces shall be polished on completion. Large areas such as floors shall be wet polished by means of approved machines using a No. 140 Carborundum Abrassive stone or equally approved. Any surface too small for convenient machine polishing may be polished by hand using a No.140 carborundum stone and clean potable water. Care must be taken during any polishing operation not to damage any angles or arise.

Terrazzo tiles, skirtings, precast terrazzo units etc., shall generally be applied in accordance with the foregoing, except that the chamfered edge of the skirting shall be against the finished wall surface.

e) Marble Slabs:
Marble slabs shall be fixed solid on bed of cement and sand (1:4 nominal mix) 20

mm thick with tight joints grouted in lime putty. A protective slurry of lime putty at least 3 mm thick shall be applied to the marble pavings and subsequently cleaned off.

Treads to stairs shall be fixed solid on a bed 15 mm thick. Risers to stairs shall be fixed solid on a backing 10 mm thick.

Window sills shall be bedded hollow on plaster dabs and pointed all around with white cement and sand mortar (1:4 mix).

Skirting shall be fixed solid on a backing 10 mm thick. Joints skirting shall be arranged to coincide with joints in adjacent pavings.

Rounded arises, nosing and mouldings shall be adequately protected by means of timber casings or lime putty coatings.

Treads, risers, skirting and window sills shall be grouted and protected in a manner similar to pavings.

The exposed faces and edges of all marble shall be cleaned or polished smooth as required and shall be free from scratches or other defects.

f) Marble Linings:
Marble lining slabs shall be fixed with copper cramps and hooks and plaster dabs leaving an air space of 12 mm behind the slabs to prevent transfer of soluble salts from the backing material.

The size, type and number of cramps and hooks and the details of fixing thereof shall be as required by the Engineer and in accordance with an approved method.

Exposed edges and mouldings shall be protected by means of timber casings or lime putty coating.

The exposed faces and edges of all marble shall be cleaned, polished smooth as required, and shall be free from scratches or other defects.

g) Cement and Sand Tiles:
Cement and sand tiles shall be laid and bedded direct on to concrete sub-floors using a cement and sand screed (1:4 nominal mix). This screed shall be a minimum of 23 mm thick. The total thickness of cement and sand screed and tiles shall not exceed 50 mm.

All tiles shall be laid with square joints and finished to a true and flat surface.

All tiling shall be grouted upon completion using neat cement of a color to match the tiling. Care shall be exercised to fill all joints completely. Any surplus grout shall be cleaned off the face of the tiling and surrounding surfaces immediately and all tiling shall be carefully cleaned off.

h) Precast concrete slabs:
Precast concrete slabs shall be laid and bedded as shown on the Drawings and by one of the following methods:

- On a well compacted layer of sand having a loose thickness of 10 mm, laid with sand filled joints 2 cm. wide and finished to a true and flat surface.

- On a 50 mm cement and sand screed (1:4 mix) laid with square cement mortar closed joints 2 cm. wide and finished to a true and flat surface. Care shall be exercised to fill all joints completely.

All precast concrete slabs shall be laid in bays not exceeding 10 m in length and the bays shall be separated by an expansion joint 2.5 cm. wide.

ROOFER

4E.55 GENERAL:

On completion, all roofs are to be left sound and water tight and in a neat and clean condition before handing over. All roof finishes shall be carefully worked or fitted around pipes or openings.

4E.56 CORRUGATED STEEL ROOF:

Corrugated steel roofs shall be of corrugated galvanized steel sheeting conforming to BS 3083.

The thickness of the sheeting shall be either 1.0 mm or 0.8 mm or as called for in the Particular Specification or as shown on the Drawings. Zinc coating shall be type 180 for 1.0 mm and type 150 for 0.8 mm sheeting respectively.
Hooks, bolts, nuts, drive screws, and washers shall be to BS 1494.

Sheeting shall be fixed to the satisfaction of the Engineer with side overlaps of two corrugations and both edges turned downwards. End caps shall have a minimum overlap of 5 cm. in excess of the distance between purlin centres.

In the case of wood framing, sheets shall be secured to wooden purlins at centres not exceeding 30 cm. by galvanized drive screws 75 mm long with galvanized diamond-shaped washers and load sealing washers.

All holes for bolts, drive screws, shall be punched from the underside of the sheets and shall be on the crown of the corrugations.

Galvanized steel ridge capping shall be supplied and fixed to the wood or steel purlins described above.

4E.57 CORRUGATED ALUMINIUM ROOFS:

Corrugated aluminum roofs shall be of corrugated aluminum sheeting conforming to BS CP 143.

The thickness of the sheeting shall be either 1.0 mm or 0.8mm or as called for in the Particular Specification or as shown on the Drawings.

Fixing accessories including bolts, nuts, drive screws, and washers shall be to BS 2465.

Fixing shall conform to BS CP 143, Part I, "Sheet Roof Coverings - Aluminum corrugated and Troughed Sheet" except that on sloped roofs, side overlaps shall be two corrugations and end caps shall be a minimum of 25 cm.

4E.58 PLASTIC CORRUGATED ROOFING:

Plastic corrugated sheets where required shall be an approved make and shall be fixed in accordance with the manufacturer's instructions.

4E.59 FLAT ROOFS:

The provisions of the Concrete Section shall apply to the construction of solid reinforced concrete roofs and to hollow slab roofs. The actual finish is to be as specifically shown on the Drawings and / or as described in the Particular Specification but will generally consist of a combination of the following materials:

a) Lightweight Concrete:
Light weight concrete screeds for obtaining falls or as an insulating layer shall be of an approved type of foamed concrete. The materials shall be measured, applied and cured in accordance with the manufacturer's instructions and to the satisfaction of the Engineer. Mixing shall take place in mechanical mixers of approved design. In all cases the finished screed shall have the properties described in the Particular Specification, or as shown on the Drawings regarding the density, permeability and insulating value.

b) Vermiculite Screed:
Vermiculite screeds for obtaining, falls or as an insulating layer shall consist of vermiculite aggregate and cement. The grade of vermiculite aggregate shall be

as required in the Particular Specification or as shown on the Drawings. The vermiculite aggregate shall be an exfoliated micaceous mineral aggregate, incombustible and chemically inert, obtained from an approved manufacturer and graded in accordance with the following table.

TABLE (8.1). GRADING DETAILS – VERMICULTE

Grade Number	Nominal Grading	Density kg/m^3
5	9.5	60 - 68
6	12.7	56 - 68

The vermiculite shall be delivered to Site in the manufacturer's containers which shall be clearly marked to show the name of the manufacturer, the grade of vermiculite contained therein. The vermiculite shall be stored in a covered store raised off the ground and the bags stacked not more than 300 cm. high.

Gauge boxes shall be used for the measurement of vermiculite and the following mixing table shall be strictly observed.

TABLE (8.2). VERMICULITE MIX

Nominal Mix	Vermiculite (m^3)		Cement (Kg.)	Water (Litres)
	Grade 5	Grade 6		
8:1	1.00	-	150	200
8:1	-	1.00	150	200

Mixing shall be carried out by an approved machine. The machine used shall be counter current rotating paddle type mixer operating at the speed recommended by the manufacturer. The water shall be placed in the mixer followed by the vermiculite and mixing shall be carried out until the water has been distributed among the vermiculite. The cement shall then be added and further mixing shall take place until all the materials are uniformly distributed.

It is extremely important to ensure that the mixing period is kept as short as possible in order to prevent compression of the vermiculite. For this reason ordinary concrete mixers of the revolving drum type are unsuitable and shall not be used.
It is also important that the water content be kept to the minimum possible to allow for the proper hydration of the cement. Sloppy mixes shall not be used. An even consistency free from lumps and excess water is required. As a site test for consistency, a handful of the mix when firmly gripped should just release water.
Placing of the vermiculite mix shall take place immediately after mixing. The

vermiculite screed shall be laid in alternate bays not exceeding 16.00 square meters in area to a minimum depth of 5 cm. The vermiculite mix shall be carefully spread by means of a rake to a depth 12.5% greater than the finished thickness required and shall then be slightly tamped and lightly trowelled down to its finished thickness.

The vermiculite screed shall be cured as shown in the Concrete Section above for a period of seven days and during this time the screed shall not be subjected to traffic of any kind.

After curing, the vermiculite screed shall be protected by a layer of cement and sand mortar (1:4 mix). This topping shall be well trowelled to ensure proper adhesion with the vermiculite screed.

The topping shall be cured as shown in the Concrete Section above for a period of seven days as described above for screeds. Alternatively the cement and sand topping may, with the approval of the Engineer, be applied immediately after trowelling the vermiculite screed and cured with it.

If roofing felt is to be laid, the surface of the topping shall be finished flat and true. The screeds and topping shall be allowed to dry out thoroughly before subsequent roofing operations are carried out.

Vermiculite screeds and cement and sand topping layers shall not be laid during rain.

c) Concrete and Mortar Screeds:

Concrete screeds for obtaining falls shall be as shown in the Concrete Section. Cement sand screeds shall be (1:6 mix) as shown in Table 8.3 below. Both types of screed shall be finished flat and true where felt roofing is to be fixed on the screeds. The thickness of screeds will be defined in the Particular Specification or as shown on the drawings.

TABLE (8.3). SAND CEMENT SCREED

Nominal Mix	Cement (Kg)	Sand (m^3)
1 : 6	250	1.00

d) Cork, Expanded Polysterene, Fiberglass, etc.

Cork, expanded polysterene, fiberglass or any other approved materials, where required, shall be laid and fixed in accordance with the manufacturer's instructions.

e) Tiles.

Terrazzo or cement and sand tiles shall be manufactured and laid as described under the Pavior Section above.

Tilted tile skirtings shall consist of a triangular fillet of concrete or cement and sand mortar (1:6 mix) or vermiculite and cement (8 : 1 mix) with a row of 20 cm. x 20 cm. x 2 cm. terrazzo or cement and sand tiles bedded in cement and sand mortar (1:4 mix) to form a skirting to match the tiling. The top edge of this tile skirting shall be let into the wall and the joint carefully pointed.

f) Expansion joints.

Expansion joints in vermiculite concrete or cement and sand screeds and toppings and in tilling, shall be formed where and as required and shall be continuous throughout the depth of screed or screed and toppings.

The expansion joints shall generally be filled as required and sealed with 2 cm. depth of resilient liquid polysulphide polymer sealant approved by the Engineer, finished with a concave joint pointed to depth of 1 cm. below the surface.

The sealant shall be applied strictly in accordance with the manufacturer's instructions.

All surfaces which will be in contact with the sealant shall be primed with an approved primer made by the manufacturer of the sealant. Care shall be taken to prevent staining of the adjacent surfaces when filling the joint. Expansion joints shall continue into the tilted tile skirtings and fillets.

g) Felt Roofing:

Felt shall be applied for damp roofing and water proofing either under tiling or crushed aggregate finishes as required by the Particular Specification or as shown on the Drawings.
All felt roofing shall be of a type suitable for use in tropical climates similar to that of Kuwait and shall comply with any of the following:

i) To BS 747, Class I, Type IC, 'Self finished Bitumen Felts' nominal weight not less than 1.4 Kg/ Sq.m.

ii) To ASTM D 226, 30 lb. Type, 'Asphalt Saturated roofing felt' nominal weight not less than 1.4 Kg./Sq.m.

iii) To BS 747, Class 2, Type 2B, 'Self Finished Bitumen Asbestos Felts' nominal weight not less than 1.4 KG./Sq.m.

A minimum of two layers of felt shall be used.

The felt shall be thoroughly bonded to the roof or screed and between layers. Care shall be taken to ensure that all surfaces upon which felt is to be laid are dry, smooth, and clean.

The bonding shall be by means of bitumen (60 / 70) penetration applied hot as a continuous coating to an average thickness of not less than 1.5 mm and not more than 2.0 mm so as to give a complete coat over the whole area at the rate of not less than 1.5 kg/ sq.m. and not more than 2.0 Kg/sq.m. for each bonding coat.

The felt shall be laid with 15 cm. side and end overlaps which shall be staggered.

The felt shall be carried up the walls, etc., over fillets to form a skirting continuous with the roof covering. The skirtings shall be bonded to the fillets and walls and shall be not less than 15cm. in vertical height.

The felt shall be dressed and bonded into rainwater outlets and under flashings.

h) Bituminous Compound Finishes:
Bituminous compound finishes where required shall be used strictly in accordance with the instructions of the manufacturer.

i) Crushed Aggregate Finishes:
Where crushed aggregate finishes are required on top of roofing felts, the aggregates shall be clean and white and bonded to the felt with bitumen (60 / 70 penetration) applied at a rate of not less than 1.5 Kg/Sq.m.

Aggregates shall pass 12.7 mm (1/2 inch) sieve and be retained on a BS No.10 sieve (1.68 mm). The rate of application shall be not less than 10 Kg/Sq.m.

The bitumen shall be applied hot as a continuous coating and the aggregates spread evenly on top while the bitumen is still hot, to obtain a good bond. The aggregate shall then be rolled down with a light hand roller.

CARPENTER

4E.60 GENERAL:

Carpenter's work shall include all structural and temporary timber work and shall be carried out in accordance with the Drawings, the principles of good construction and to the satisfaction of the Engineer. It should be noted that sizes shown on drawings are finished sizes.

4E.61 MATERIALS:

a) Timber shall be classified in accordance with the Groups listed under and conform to the requirements of Joiner Section.

b) Generally structural timber work shall be executed in Group 1 softwood or other coniferous timbers considered by the Engineer to be similar and equal.

c) Where permitted, structural timber work may be carried out in Group 2 or Group 3 hardwood or other deciduous timbers considered by the Engineer to be similar and equal.

d) All timber shall be properly seasoned and shall be sawn square, straight and true and shall be free from all objectionable defects.

e) Temporary timber work may be executed in any timber chosen by the Contractor who shall remain responsible for the safety and sufficiency of such temporary work. In all cases the timber for temporary work shall be free from decay or insect attack except that dead pinworm holes may be permitted. The Contractor shall be responsible for clearing away all temporary timber work upon completion.

f) Fibreboard shall be in accordance with British Standard No. 1142 (Standard hardboard).

g) Hardboard shall be in accordance with British Standard No. 1142 (Standard hardboard).

h) Chipboard shall be in accordance with British Standard No. 2604 or other approved similar standard.

i) Timber connectors where used shall be two single-sided toothed plate (round or square) for demountable joints or one double sided toothed plate (round or square) for permanent joints to BS 1579.

j) Plugging to walls shall be carried out by the following means:

- An approved patent fibre plug fixed in accordance with the manufacturer's instructions.

- An approved plastic filling used in accordance with the manufacturer's instructions.

- Hardwood plugs cut on the twist.

- Softwood plugs shall not be used.

k) Nails shall be in accordance with BS 1202.

4E.62 JOINTING:

Work described as framed shall be properly jointed together, wedged and bolted where necessary in accordance with the principles of good construction and to the satisfaction of the Engineer.]

JOINER

4E.63 GENERAL:

Joiners work shall include all finishing and non-structural timber work and shall be carried out in accordance with the principles of good construction and to the satisfaction of the Engineer. It should be noted that sizes shown on Drawings are finished sizes.

4E.64 MATERIALS:

a) Timber:

Timber shall be classified in accordance with the groups listed below:

Softwood Group 1	Hardwood		
	Group 1	Group 2	Group 3
Douglas fir Longleaf pine European red wood	Burma teak	Ahmar Faini Zan	Abulhaz Montaig

The timber to be used for each portion of the Works shall be according to the above classification. In general, joinery work shall be executed in first grade Burma teak. Where required, work which is to be painted or work which is not to remain exposed shall be executed in Group 2 hardwood or other deciduous timbers considered by the Engineer to be similar and equal. Group 3 hardwoods are included above for reference purposes and generally shall not be used for joinery work.

All timber shall be properly seasoned and shall be planed square, straight and true and shall be free from the following defects:

- Sapwood, splits, ring shakes, soft pith.

- Knots of any description in surfaces for staining or polishing and in glazing bars.

- Knots exceeding 2 cm. mean diameter on one half the width of the surface.

- Decayed or dead knots unless cut out and plugged.

- Loose knots or knot holes unless cut out and plugged.

- Pitch pockets.

- Decay and insect attack including pin worm holes.

In jointed panels each piece shall be of the same species.

Joinery for staining or polishing shall have all surface of the same species and some character of grain.

All plugs inserted after cutting out defects shall be the full depth of the hole and the grain of the plug shall run in the same direction as the grain of the piece.

b) Plywood:
Plywood shall conform to the requirements of BS 1455, WBP bonded type.

Its minimum thickness shall be 5 mm.

Plywood face veneers shall be to BS 1455, Grade I.

Plywood adhesives shall be to BS 1203, WBP Grade.

Plywood shall be obtained from an approved manufacturer to the correct thickness specified. The Contractor will not be permitted to make up the required thickness by gluing together sheets of thinner plywood.

c) Face Veneers:
Face veneers shall be hard, durable and capable of being finished easily to a smooth surface. They shall be free from knots, worm and beetle holes, splits, glue stains, filling, or inlaying of any kind or other defects.

Face veneers shall be applied to one or more sides as shown on the Drawings.

Timber for face veneers shall be as shown on the Drawings but in accordance with the following classification:

Group 1,	Burma Teak.
Group 2,	Ash. / Birch. / Oak.
Group 3,	Mahogany. / Walnut.

The Engineer may approve the use of other hardwoods which he considers equal.

4E.65 WORKMANSHIP:

All joinery work shall be accurately set out, framed and executed in accordance with the Drawings.

Joinery shall be cut and framed at an early stage, but shall not be glued or wedged until the building is ready to receive it.

Framed work shall be properly morticed and tenoned, wedged, glued, and cramped together and dowelled where necessary. All external joinery work shall be put together with a thick mixture of red or white lead and linseed oil or with synthetic resin adhesives to BS 1204, WBP Grade.

The use of nails for fixing any items of joinery will not be permitted. Springs may be used for glazing beads only.

Screws shall be in accordance with BS 1210.

All screws and bolts shall be countersunk and puttied or pelleted and all springs shall be punched and puttied.

4E.66 DOORS:

Doors shall be framed to the sizes shown on the Drawings. Double doors shall have meeting heads screwed on. Glazing if required shall be of twice rebated section. Panels to doors shall be moulded both sides and let into framing for a minimum depth of 1 cm. all round as shown on the Drawings.
Flush doors shall be framed in softwood and covered with plywood as indicated. The horizontal framing members shall have ventilation holes drilled in the vertical direction to avoid damage due to expansion of trapped air. A teak edging shall be securely joined and dowelled to the framing all round the exposed edges and shall be splayed or rebated to take the edge of the plywood facing. Lock rails or fixing blocks shall be built into the framing and their positions marked on the facing.

4E.67 WINDOWS AND SASHES:

Windows and fanlight sashes shall be framed to the sizes shown on the Drawings. Sashes hung folding shall have meeting beads screwed on. Glazing bars if required shall be of twice rebated section.

4E.68 HATCHES AND SHUTTERS:

Hatches, shutters and similar item of joinery shall be framed to the sizes shown on the Drawings.

4E.69 FLY SCREENS:

Fly screens to doors shall be framed and braced with rails. The screen shall consist of 0.70 mm approved copper or galvanized steel fine wire mesh which shall be attached by beading.

Fly screens to windows shall be framed with rails and stiles and shall consist of approved copper or galvanized steel fine wire mesh of 0.42 mm, beaded on.

4E.70 FRAMES:

Frames to doors, windows, and fly screens shall be provided and built in to the sizes shown on the Drawings. Frames shall be securely tied to walls by means of steel or similar metal cramps, galvanized or dipped in bitumen or as follows:

Door Frames	:	Three cramps to each side.
Window frames	:	Two or more cramps to each side according to size.

Doors, windows, etc., shall be carefully and accurately fitted to the frames to give a uniform clearance of not more than 3 mm all round.

4E.71 DRAINING BOARDS:

Where required by the Particular Specification ,or shown on the Drawings, teak draining boards shall be provided and fixed in accordance with the provisions hereunder.

The draining boards shall consist of one piece of timber or alternatively two or more pieces may be joined together either by means of machined tongued and grooved joints or by loose tongues. The loose tongues shall be of either the same timber as the boards or of plywood manufactured as described above.

The draining boards shall be assembled with either synthetic resin adhesives to BS 1204 Grade WBP or with lead linseed oil paste.

The ledges shall be size 50 mm wide x 30 mm thick and shall be secured across the underside of the draining board by at least four countersunk brass screws fixed through slotted holes. In cases where the draining board is made up of more than one piece of timber the ledges shall be secured by at least two screws into each piece.

The beads to the draining board shall be size 40 mm high x 12 mm thick and their edges shall be rounded. The beads shall be fixed to three edges of the draining

board by means of countersunk brass screws. The grooves shall be tapered from a semi-circular section of 51 mm radius at the lower end and running out to coincide with the surface at a distance of 10 cm. from the upper end of the draining board. The grooves shall be formed at the rate of one for each 10 cm. width of the board. To prevent water from running back a trotting groove size 5 mm x 5 mm shall be cut in the underside of the board, parallel to and at the distance of 25 mm back from the drip edge.

The draining boards shall be fixed to obtain a gradient of 2 percent on either two black steel brackets 30 cm. long or on bearers plugged and screwed to walls or on framing according to position and as shown on the Drawings.

4E.72 FITTINGS:

In connection with fittings such as wardrobes and cupboards, the doors, frames, drawers, rails, and framing, etc., shall be properly and accurately framed together as shown on the Drawings.

4E.73 SHELVING:

Wrought shelving shall be constructed and fitted as shown on the Drawings supported with bearers on framing or brackets.

4E.74 SUNDRIES:

Architraves and cover beads where required shall be wrought and moulded screwed on to frames.

Rails for hat and coat hooks and the like shall be wrought and chamfered plugged and screwed to walls.

Glazing beads where required shall be wrought splayed and rounded and shall be neatly mitered and fixed with small brads or lost head nails.

4E.75 SCRIBING:

All joinery such as architraves, beads, etc., required to fit against the contour or irregular surfaces shall be accurately scribed to ensure a close butt connection.

4E.76 FINISH:

All joinery which is to be polished, varnished or painted shall be finished smooth and clean by rubbing down with fine glass paper.

IRONMONGER

4E.77 GENERAL:

The Contractor shall provide and fix the ironmongery required as shown on the Drawings complete including all necessary screws, bolts, plugs, and other fixings.

The use of nails for fixing ironmongery will not be permitted. The Contractor shall hand over all work in a finished state and to the satisfaction of the Engineer.

All ironmongery shall be of first quality and shall be obtained from an approved manufacturer.

The Contractor will be required to submit for approval samples of all items of ironmongery he proposes to use.

All doors shall be provided with a rubber door stop plugged and screwed to the floor and all opening sashes of windows shall be provided with friction stays. The sizes, materials, finishes, type, and quality of ironmongery shall be as shown on the Drawings.

4E.78 FINISH:

The finish of the various items of ironmongery shall be as shown on the Drawings.

4E.79 FITTING AND TESTING:

All screws used for fixing ironmongery shall be of the correct type, material, finish, size, and shape to the satisfaction of the Engineer.

The hinges on which doors, windows, flyscreen doors, etc., are hung shall be carefully housed or let in to the door, window, flyscreen door, etc., and to the frames.

All fittings shall be removed before starting any painting operations and shall be refixed in place after all painting works are completed and approved by the Engineer.

All ironmongery shall be carefully wrapped and protected until the completion of the work and any items or parts which are damaged or defected shall be replaced at the Contractor's expense before handing over.

On completion, all locks, catches, and similar items of ironmongery shall be properly cleaned tested and oiled and all keys shall be clearly labelled with metal or hardboard tags size approximately 5 cm. x 2 cm. securely fixed to the keys and handed over to the Engineer.

The doors of high voltage substations shall be fitted with 'Union' cylinder rim night latches of the type that may be opened with a master key with all required details.

METAL WORKER

4E.80 GENERAL:

All materials shall be free from scale, rust, damages or defects. All welding, brazing or hot forging shall be carried out by approved processes.

All metal works shall be approved by the Engineer before starting painting works

4E.81 STRUCTURAL STEEL WORK:

All structural steel work shall be provided and fixed complete with all plates, cleats, bolts, etc., cut to lengths and sizes and drilled as shown on the Drawings.

a) The quality of the steel work generally shall be in accordance with BS 15 (Mild Steel for General Structural purposes).

b) Steel tubes shall be seamless tubes in accordance with BS 1387 or BS 1775.

c) All bolts and nuts shall be to Wit worth standard. Block bolts shall be in accordance with BS 916. Bolts shall be of sufficient length to show at least one full thread beyond the nut after tightening.

d) Washers, where used, shall be to BS 3410 with a tolerance of 1.1/2 mm (1/16 inch) on the diameter of the hole.

The design and detailing of connections and workmanship shall be in accordance with the Drawings and BS 449 (The use of structural steel in Building).

All steel work fabricated off site shall be painted one coat of red lead primer before being dispatched to the Site.

4E.82 WINDOWS AND DOORS:

The following remarks relating to metal windows shall cover also metal casement doors and, where applicable, partitions as well.

Generally metal windows shall be supplied complete with frame, fixing lugs and glazing clips or beads. Composite windows shall be supplied complete with the necessary transoms and mullions. Generally the windows will be required to open inwards.

Mild steel windows shall be manufactured in accordance with BS 6510 with regard to materials and workmanship. The windows shall be formed of hot rolled mild steel sections, electricity welded, and rust proofed by either hot or cold galvanizing, metalizing or sheradizing process as required. The rust-proofing shall be sufficient

to withstand the 72 hour salt-spray test as provided for in BS 1391.

Opening sashes shall be fitted with steel hinges having brass pins. Pivoting sashes shall be fitted with bronze ring centres. Side hung or vertically pivoting sashes shall be fitted with sliding stays and handle fasteners with two-point noses as shown on the Drawings. Top hung or horizontally pivoting sashes shall be fitted with brass peg stays. Bottom hung sashes shall be fitted with brass lever catches and, according to size, one or two steel side arms each.

When bolting to diminishing sections, tapered washers shall be used.

Riveting shall be carried out in accordance with BS 449 and BS 275 using rivets with snap heads and points and of sufficient length. Surfaces in contact with members to be riveted shall have all burrs removed to ensure perfect contact. Riveting shall be carried out carefully so as to avoid distortion of the riveted members.

Welding shall be carried out in accordance with BS 5135 or using electrodes as specified in BS 639. Welders shall be suitably qualified and experienced and, if so required by the Engineer, shall produce evidence or their capability of executing the test welds specified in BS 4872.

Aluminum windows shall be manufactured of extruded sections of aluminum alloy, flash welded. Fittings shall be of aluminum alloy in accordance with BS 1331.

Flyscreens shall be applied to all opening leaves of windows, consisting of a separate metal sub frame filled in with flywire as previously described. The flyscreen shall be adequately secured with suitable clips, set-screws or turn-buckles and shall be removable for maintenance purposes. Flyscreen doors shall consist of similar sections to the metal casement doors and shall be fitted with removable panels of flywires in a manner similar to that described for window flyscreens.

4E.83 ALUMINIUM WORKS:

General.

1. All aluminium works whether shown on Drawings or not shall consist of sections as approved by the Ministry of Public Works.

2. The aluminium sections shall only be supplied from and fabricated by approved factories and under no circumstances shall such factories be permitted to sub-contract the supply or fabrication of all or part of the aluminium works.
3. Aluminium works shall be fabricated in accordance with the methods approved by MPW using approved equipment.

4. The Contractor shall submit all necessary Workshop Drawings, details and specifications for the approval of the Engineer. The Contractor shall ensure that the material and fabrication of the aluminium works are in accordance with the approved drawings and / or the comments of the Engineer. Finally, the Contractor shall be responsible for the installation to be carried out in accordance with the best practices and all to the satisfaction of the Engineer.

5. Once the Drawings have been approved, the Contractor shall supply samples for approval of all the different aluminium sections and of all the materials he intends to use in connection with the aluminium works. If necessary he shall also supply complete made-up windows , doors and the like for approval. Such samples shall show the method of fabrication, fixation and operation.

6. No part of the aluminium works shall be in contact with any plaster-work or any material that may damage the anodised finish of the aluminium. If an aluminium unit is required to be fixed to a plastered surface then a whitewood timber sub-frame (minimum 80 x 15 mm) shall first be fixed and all plaster-work completed before installing the aluminium unit.

7. The permitted dimensional tolerance between the fabric of the building and any aluminium works shall be 3 - 5 mm. Any unit exceeding this shall be removed and a new unit fabricated to replace it at the Contractor's own expense and to the satisfaction of the Engineer.

8. The Contractor shall not install the aluminium works until all the locations for the works are suitably prepared, all openings and square, all surfaces are to the required levels, etc. Under no circumstances will it be permitted to install an undersized unit and fill in the subsequent gaps.

9. The space between any aluminium unit and the fabric of the building (maximum tolerance as above) shall be filled with grey colored mastic of an approved manufacture and from an approved supplier. The mastic shall be injected by means of a gun applicator in such a manner so as to avoid the passage of air.

10. All the above is to be considered as a basic for aluminium works of different type and designs unless otherwise mentioned in the Drawings.

Specific Applications.

1. All aluminium units of whatever shape, profile or section shall be fabricated from hollow aluminium Sections of aluminium mixed with magnesium and silicone (aluminium alloy / 6063-TS). It shall have a tensile strength of not less than 1550 Kg./cm^2. The finished unit shall be capable of withstanding a windload of 100 Kg./M^2 without deflecting more than 1/175 times the span of the opening.

2. The minimum thickness of the main profiles shall be 3 mm. thick unless otherwise stated on the Drawings. Glazing bars or the like shall be of a lesser thickness (but not less than 1.8mm).

3. The exposed surfaces of the aluminium works are to be chemically treated according to the Kuwait Standard Specification No. KS 24. Aluminium works on the external face of buildings shall be treated to a degree not less than 20 microns, those internally to not less than 15 microns. All the supporting aluminium works, posts, frames, and the like of whatever shape are to be straight without any deflection whatsoever and have properly formed angles.

4. All the aluminium sections shall be fabricated from uniform extrusions and have consistent external surfaces, color and anodisation. The Contractor shall submit written evidence that the aluminium has been produced in approved sources and in accordance with the appropriate International Technical Specifications for Aluminium works.

5. All the aluminium sections shall be wrapped in either special paper or polythene sheeting at the factory before being sent to Site. The protective wrapping shall be such that after removal, it shall leave no trace or mark on the sections. Such wrapping shall not be removed until the project is practically complete.

6. When transporting to Site all aluminium units of whatever size or area shall be stacked horizontally. Between each unit wooden spacers shall be placed in order to prevent twisting, bending, buckling, etc., of the units.

7. All the aluminium sections in contact with any concrete products, e.g. blockwork, concrete beams, etc., shall first be protected by being coated with anti-corrosion paint e.g. (Zinc chromate pigment in synthetic resin vehicle).

8. No welding of the sections shall be permitted during fabrication or installation of the units, except where urgently required and approved by the Engineer.

9. All the units shall be assembled using stainless steel screws. They shall be fixed in position by means of wall plugs using stainless steel screws. The fixing points shall be at a maximum of 50 cm. centre both horizontally and vertically. All the screws for assembling and / or fixing each unit are to be uniform throughout.

10. All windows, doors and the like shall have double neoprene gaskets. One gasket shall be fixed to the frame and the other to the leaf. The gaskets shall be of sufficient thickness so as to make the unit air tight and dust proof. Fibreglass brushes will not be permitted, except fixed to the bottom of the door leaf. In

such cases, the fibreglass brushes shall be contained in a purpose made profile which shall be fixed at the appropriate level on the door leaf.

11. Hinged external windows are to have an independent aluminium fly screen fixed externally in such a manner so that the fixing screws are not visible. Sliding external windows shall have a fly screen fixed externally within the frame Such flyscreens are to be of aluminium wire mesh type 14 and of 27 gauge.

12. The type and dimensions of the aluminium alloy curtain walling shall be as shown on the Drawings.

    The curtain walling shall consist of mullions, transoms and head and stile members, to the module shown on the Drawings, fitted together with spigot and socket joints set in non-hardening mastic.

    The curtain walling shall be of adequate strength to resist the wind pressures, panel loadings to be as shown on the Drawings or in the Particular Specification and shall be securely anchored to the building by means of bolts, channels etc., to the approval of the Engineer. Adequate provision shall be made to accommodate thermal movement and suitable weathering devices shall be incorporated.

    The curtain walling shall be supplied in either standard or anodized finish. In the latter case the units shall be protected by a plastic covering applied by the manufacturer and stripped off when installation is completed.

Ironmongery:

1. All hinges to be of aluminium and suitable for use with the applicable profiles. Each hinge to have a stainless steel pin with a plastic sleeve so as to ensure ease of operation and keep it free from corrosion.

2. All vertically hinged windows to be operated by means of an aluminium handle having a concealed tongue fixed to an invisible internal lever each lever shall have a plastic sleeve not less than 3 cm in length which will locate in the aluminium frame in order to secure the window.

3. Vertically hinged windows to a height of 150 cm to have a minimum of 3 numbers of hinges.

4. Horizontal hinged windows to be provided with 1 anodised aluminium tongue with 2 hinges and 2 stays permitting the window to remain open to an acceptable degree (eg. 45°).

5. All external inaccessible windows shall have a 'Z' shaped frame fixed to their frame so that the aluminium fly screen can be fitted from within the building.

6. Sliding window and door leaves to run on a minimum of 2 runners and to be equipped with an anodised aluminium handle capable of securing the window / door in a closed position.

7. All leaves in a sliding frame, whether sliding or fixed are to have a fibreglass brush of length suitable for the profiles so as to make the unit airtight and dustproof.

8. All fibreglass brushes whether on the frame or the leaf are to be doubled.
9. All single leaf hinged doors shall have 4 hinges and a pair of anodised aluminium handles and a lock set. This lock set shall switch with 2 throws and 1 latch.

10. All double leaf hinged doors shall have 4 hinges in each leaf and 2 pair of anodised aluminium handles and a lock set as above. In addition each leaf shall have a 'tower' bolt of neither less than 8 mm in diameter nor less than 15 cm in length and with a plastic cap on the head of the bolt.

11. All the hinged doors, single or double, except doors to A/C or Electrical rooms shall have hydraulic overhead door closers to match the doors.

12. All leaves in double or single doors shall have a rubber stopper 10 cm. from the face of the wall, 4 cm in diameter and fixed by means of wall plugs and screws.

13. All door handles shall be of suitable design and have an internal square screw with lock to prevent sliding of handle in addition to fixing bolts.

14. All the main external doors shall be provided with special handles to be selected and approved by the Engineer.
15. Swing doors shall have brushes between the door leaf and the frame such that the door shall be airtight and dustproof. They shall have double brushes of suitable length on the bottom of the door leaf which shall project not less than 3 - 4 mm in length.

16. All swing doors shall have a heavy duty double action floor spring with an open angle for each leaf more than 90 °C.

17. All swing doors shall have a handle, lock, and foot stopper all as before described. In addition double swing doors to have 2 No. tower bolts, 1 to each leaf as described before.

18. All doors described on the Drawings to be fire resistent shall be fabricated according to the specification as directed by the Engineer and in accordance with the requirements of the Kuwait Fire Brigade. They shall all have self closer sets as approved by the Engineer.

19. All escape and emergency doors as shown on the Drawings and approved by the Engineer shall be equipped with panic bolts.

20. All doors and windows with insert panels of whatever type e.g. glass, glazal, etc., shall have a suitable rubber sealing strip to both sides designed to match the aluminium profiles. It shall be fixed in a proper manner, all angles to be neatly cut with no gaps allowed.

21. Samples of all ironmongery and any other materials to be used in connection with the aluminium works shall be prepared on a suitable sized aluminium board for the approval of the Engineer. This board shall be kept by the Engineer as a reference until the completion of the Project.

22. All the ironmongery shall be fabricated by a well known international source in Germany, Britain or the like and shall be of a recognised make and approved by the Engineer.

Pricing and Method of Measurement.

The price for the aluminium works shall include but not be limited to the fabrication, supply, and installation of complete units of different shapes and sizes. It shall include for forming openings or the like within the aluminium works and for all necessary fixing of the aluminium works to the fabric of the building. Also included shall be the ironmongery, glass, fly screen of wire mesh, and all other materials necessary for the completion of the aluminium works in accordance with the Specifications, Drawings, good practice, and to the satisfaction of the Engineer.

All units e.g. doors, windows, and the like shall be measured by number. Items such as partitions, screens and the like may be measured in square metres or as described in the Bill of Quantities.

4E.84 MISCELLANEOUS:

Wrought steel balustrades shall be provided to staircases and balconies as shown on the Drawings. Burglar bars and safety bars shall be provided to windows where shown on the Drawings.

Clamps for fixing timber door and window frames shall be 20 cm. long x 3cm. x 3mm section and shall have one end bent and twice drilled for screwing to frame and other end fishtailed for building into walling. Clamps shall be galvanized or dipped in

bitumen before fixing.

Mild steel ladders where required shall be as shown on the Drawings.

Metal roller shutters shall be provided to sizes shown on the Drawings. Each roller shutter shall be constructed of heavy-guage metal slats and shall be complete, including channel iron guides, roller box, spindle, and counter balance springs and with staple welded to door, hasp set in concrete floor and padlock.

4E.85 SPECIAL INSTRUCTIONS GENERALLY:

a) Brushes which have been used for emulsion paint are on no account to be used for any other paint work.

b) No thinners to be used other than those specified by the manufacturer.

c) Every practical precaution must be taken to keep down and exclude dust before and during application of the paint and during the whole of the drying perying period.

d) No painting is to commence on any surface until a perfect smooth surface (which includes providing putties and preparation of that surface) has been approved by the Engineer and no finishing coat is to be applied without approval of the Engineer.

e) The Contractor shall repair at his own cost any work where the paint finish is found to be in the opinion of the Engineer, unduly thin.

f) No painting is to be carried out when raining and all surfaces must be thoroughly dried before work commences.

g) All paint work must be protected during execution and dust sheets are to be made available if required by the Engineer.

h) The tints of undercoats are to be approximate to the finishing coat but to be of sufficient difference in each succeeding coat to indicate and prevent missing areas.

i) Test samples of colors to be used are to be made for each coat and approved by the Engineer before the work commences.

j) All paints are to be delivered to the site in the sealed and labelled containers produced by the manufacturer with the necessary instructions for use and on no account is any mixing to take place without the prior approval of the Engineer. A certificate or letter from the manufacturer must also be produced stating

that they have full confidence that their materials will stand up to the exposure conditions found in Kuwait.

DRAINLAYER

4E.86 GENERAL:

All storm water and sewage drainage works shall comply fully with all regulations force issued by the Sanitary Engineering Division of the Ministry of Public Works.

4E.87 SCOPE OF WORK:

The work shall comprise all soil, surface water and sewage drains, manholes, percolating pits, intercepting traps, etc., as shown on the Drawings or as directed by the Engineer.

4E.88 PRINCIPLES OF DRAINLAYING:

All drains shall be accurately laid, true to line and gradient in the positions and to the levels shown on the Drawings.

Manholes shall be set out as shown on the Drawings, and at changes in direction and gradient and points of connection.

All drain pipe runs between manholes shall be absolutely straight and to the falls and levels shown on the Drawings.
If some gradients are inadvertently omitted on the Drawings, the drains shall be laid as directed by the Engineer.

4E.89 CONSTRUCTION AND TESTING:

The Contractor shall perform all necessary excavation for drains, manholes, tanks, pits, etc., uphold sides, grade or form bottom, return fill and ram and remove surplus excavation materials as directed by the Engineer and as specified under Section of Excavator, above.

Trenches shall be of sufficient width to allow adequate working space for pipe layers and jointers, joint holes shall be formed in the bottom of trenches whenever necessary so that the pipe shall always rest on a firm and even bearing along its full length. The pipes shall be laid with the socket end against the flow and shall be kept free from earth, sand, surplus mortar and other obstructions during laying.

Before the trenches are backfilled, and at least 48 hours after the jointing has been completed, the Contractor shall test and prove the drains to the satisfaction of the Engineer. The system is to be tested in sections between manholes, by filling with water to a head not less than 90 cm. and not more than 150 cm. Pipes and manholes found to be water tight will be passed as satisfactory but the water must

be maintained until at least 50 cm. has been backfilled over the top of the pipes. Manholes failing to meet the test shall be made good at the Contractor's expense and to the satisfaction of the Engineer even if total reconstruction is required. Pipe failing to meet the test shall be taken up and the sound ones re jointed at the Contractor's expense until water tight. The Contractor shall supply all water, plant, equipment, and incidentals required for testing. The Contractor shall be held responsible for any disturbance of the drains after they have passed the test satisfactorily.

Sewage pumping mains are to be tested as shown for water mains in the Plumber Section, but the test pressure shall be 5 Kg/sq.cm.

Backfilling around the pipes and for the first 30 cm. above the top for the pipes shall be with selected granular material approved by the Engineer, well watered and compacted with care by hand so as not to injure the pipes or joints. The backfill in trenches shall be placed in successive layers each having a finished thickness not exceeding 15 cm, watered and well rammed prior to the placement of the successive layer.

4E.90 CONCRETE BEDS:

Concrete beds and haunchings shall be provided for all salt-glazed ceramic and concrete pipes laid at less than 1.5m or more than 4.0 m deep, and for any kind of pipe placed below the permanent water table, and whenever required, or as shown on the Drawings. The concrete shall be Mass concrete, 15 cm. thick below the bottom of the pipe and having a width of 10 cm. on each side beyond the outside diameter of the pipe at the top of the haunch. The haunches shall extend half way up the pipe, or as per site conditions

Whenever pipes run beneath buildings or roads, they shall be completely encased in Mass concrete. The concrete shall be 15 cm. thick at the bottom and top of the pipe and 15 cm. wide on each side halfway up the pipe.

4E.91 MANHOLES AND SEPTIC TANKS, ETC.:

Manholes, chambers, septic tanks, disintegration, and septic tanks and percolating pits shall be constructed in the positions and to the dimensions shown on the Drawings or as directed by the Engineer. The method of execution of the work shall be as described in the appropriate trades elsewhere in this Specification. Table 13.1 below shall serve as a guide for the wall thickness of manholes, septic tanks, and percolating pits, unless otherwise required by the Drawings or the Particular Specification.

TABLE (13.1). WALL THICKNESS OF MANHOLES SEPTIC TANKS AND PERCOLATING PITS

Height of wall	Reinforced concrete (cm.)	Blocks (cm.)
0 cm. to 60 cm	20	20
61 cm. to 150 cm.	20	20
151 cm. to 300 cm.	25	30
Above 300 cm.	25	40

Manholes not exceeding 100 cm. deep internally shall be constructed to the sizes shown in table 13.2 below unless specifically shown otherwise on the Drawings or ordered by the Engineer.

TABLE (13.2). INTERNAL SIZES OF MANHOLES

Description.	Internal Size (cm.)
Straight channel, not more than one branch.	60 x 60
Change of direction, not more than one branch.	60 x 60
Straight channel not more than three branches on one side.	60 x 90
Straight channel not more than five branches on one side.	60 x 120

Manholes exceeding 100 cm. depth internally shall have a minimum internal size of 60 cm. x 90 cm.

The channels in manholes bottoms shall be formed in concrete finished smooth. The channels shall be semi-circular in section and the concrete shall then be carried up vertically for a distance of 8 cm. at each side and sloped back at a minimum fall of 1:10.

The benching shall be of concrete and shall be rendered over in cement and sand mortar (1:3 mix.).

All ends of pipes shall be built into the walls of the manholes, etc. and any rendering around the pipes made good. The channels in the bottom of manholes shall be so rendered and finished as to be continuous with the inverts of the pipes.

Percolating pits shall be built circular. The lower courses shall be built honeycombed with two courses of solid block work followed by one course having 5 cm. wide open vertical joints every two headers.

4E.92 INTERCEPTING TRAP:

A salt glazed ceramic intercepting trap with cleaning arm and level-locking stopper shall be placed in cement mortar in the intercepting manhole adjacent to the Septic Tank or just inside the site boundary in case of connection to mains drainage. The built-in drop from inlet to outlet of trap shall be preserved in placing thereof.

4E.93 VENT PIPES:

The head of every drainage system shall be ventilated by use of vent pipes which shall be carried to a height of 10 cm. above roofs not used as terraces or to a minimum height of 200 cm. for roofs to be used as terraces. The vent pipe shall be fitted with a galvanized or copper wire baloon grating at the top.

Except where branches or other fittings occur, the top length of each ventilating stack shall consist of a complete length of pipe which shall be anchored 120 cm. from the top by means of a wrought steel strap fixed as described below, painted to match the pipe. Any short length required to make up the length of the stack shall be fitted immediately below the top length.

4E.94 FRESH AIR INLET:

A fresh air inlet shall be provided at the intercepting manhole. This shall consist of a vertical length of 100 mm (4 inch) cast iron drain pipe fixed to the manhole at a point just below ground level using an easy bend. At the top of the vertical length of pipe, a fresh air inlet with automatic mica flap shall be provided and jointed to the pipe with a caulked lead joint.

4E.95 PIPES AND FITTINGS:

The type and quality of pipes and fittings for conducting effluent or surface water shall be as shown on the Drawings and selected from the following:

a) Asbestos cement pressure pipes and joints as manufactured by the Kuwait Asbestos Factories or in accordance with ISO Recommendation R 160, with 'Magnani' or 'Reka' type joints having natural or synthetic rubber sealing rings. The asbestos cement drains and joints shall withstand an internal pressure tightness test of ten(10) atmospheres. When cast iron fittings are required they shall be to BS 78.

b) Concrete pipe and fitting shall comply with BS 5911.

c) Cast iron pipes and fittings shall be in accordance with ISO Recommendations R 13.

d) Salt-glazed ceramic pipes and fittings shall comply with BS 65 and shall be stamped with the mark of conformity of the British Standards Institution or Similar approved.

e) Pitch-fiber pipes and fittings shall comply with BS 2760.

4E.96 SUNDRY MATERIALS:

The cement, sand, aggregates, reinforcement, blocks, bricks, and other building materials shall be as specified elsewhere in this Specification.

The grading of sand for jointing, pointing, and bedding mortars shall be as for fine aggregate, grading zones 3 or 4, Table 2, BS 882.

The mortar for jointing drains shall be composed of 1450 Kg. of cement to each cubic meter of sand (1:1 mix), with sufficient water for a good workability, and thoroughly mixed to the satisfaction of the Engineer.

The mortar for rendering, pointing and bedding manhole covers, gratings, etc., shall be composed of 350 Kg. of cement to each cubic meter of sand (1:4 nominal mix), mixed as above.

4E.97 ACCESSORIES:

Manholes covers, gully gratings, and frames shall be cast protectively coated and complying in all respects with BS 497.
Manholes covers shall be flat and shall be Grade A (heavy duty) when in roadways, Grade B (Medium duty) when in footways and Grade C (light duty) otherwise. When used inside buildings or verandas, they shall be of the double-seal type.

Gully gratings shall be the heavy duty type when used in areas subject to motor traffic and of the medium duty type for all other areas.

Manholes covers and gully grating frames shall be bedded and pointed with cement sand mortar as described above and the rebates sealed with and the covers bedded in a mixture of grease and sand.

Step irons for manholes shall be galvanized malleable cast iron in accordance with BS 1247, General Purpose Type, with a tail length of 11.5 cm. (4.5/8 inches) they shall be built in as the work proceeds.

4E.98 JOINTS:

Joints between pipes, fittings and drains shall be executed as below:

a) Concrete to Concrete:
By well wetting the spigot and socket and wrapping one turn of approved tarred yarn gasket round the spigot end of the pipe and lightly caulking into the socket so as to occupy more than one quarter of the socket depth.

The remainder of the socket shall be filled with cement and sand (1:1 mix) mortar and a fillet formed round the joint from the edge of the socket to the barrel of the pipe at an angle of 45 degrees.

b) Salt-Glazed Ceramic to Salt-Glazed Ceramic:
As for concrete to concrete above.

c) Asbestos Cement to Salt-Glazed Ceramic:
As for concrete to concrete above.

d) Cast Iron to Cast Iron:
With tightly caulked approved hemp yarn or lead strip with either:

i) Molten pig lead tightly caulked to fill the socket, or

ii) Lead wool tightly caulked home skein by skein to fill the socket.

e) Cast-Iron stone Salt-Glazed Ceramic:
As for concrete to concrete above.

f) Cast Iron to Asbestos Cement:
As for concrete to concrete above or with special joints as specified by the Manufacturer according to the Engineer's instructions.

g) Pitch Fiber to Pitch Fiber:
By means of machine tapered spigots and sockets or couplings carefully driven together to form a water tight joint. The driven end shall be a protected socket or coupling and driving shall be carried out against a solid backstop.

4E.99 FIXING:

When fixed to walls, columns, or beams, pipes and fittings shall be kept 3 cm. clear of the walls, etc., except at sockets. They shall be fixed with galvanized screws and soft lead washers with 12.5 mm (1/2 inch) galvanized pipe distance pieces. The screws shall be securely driven for at least 4 cm. into approved plugs fixed into the wall.

Either cast-on projecting bars or holder bats of the two-section type shall be employed to secure the pipe.

4E.100 CLEANING DRAINS:

The Contractor shall remove all silt and foreign matter from drains and manholes and leave the whole in a clean and workable condition.

4E.101 TESTING ON COMPLETION:

Before backfilling the trenches and again on completion, all drains shall be tested and approved to the satisfaction of the Engineer. At all times an interval of 48 hours shall elapse between jointing and testing.

PLUMBER

4E.102 GENERAL:

All plumbing works shall comply fully with the specification for water supply issued by the Ministry of Electricity & Water / Ministry of Public Works.

The Contractor shall provide all material, labour, equipment, plant and incidentals required to execute, complete and maintain the works. The Contractor shall carry out the tests required under the supervision of the Engineer and shall make good and replace any defective work. The Contractor shall be responsible for protection of all plumbing from damage whether due to the concurrent work of other trades or otherwise, and he shall clean-up upon completion, leaving all works in perfect working order and to the satisfaction of the Engineer.

4E.103 WATER MAINS:

Water mains 80 mm diameter and larger inside the fence to the building used for fresh water shall be Ductile Iron pipe to ISO Specification 2531 or BS 4772. Pipes of diameter 60 mm and less shall be of U.P.V.C. to British Standards.

Sluice valves shall be to BS 5154 or equivalent, opening in an anti-clockwise direction. The valves shall be complete with valve caps, forged bronze spindles and gunmetal nuts and double faced with four gunmetal faces. Flanges shall be drilled to BS 10, Appendix A, Table E jointing shall be as Table 14.2 below.

The water mains shall be tested prior to being buried or otherwise covered. The valve joining the water mains to the main supply shall be closed and the open ends of the mains at the water tank stopped with appropriate means. A test pressure of 10 atmospheres shall be applied by means of a booster pump or other approved means. The test pressure shall be held for a period of at least 2 hours and the mains and joints inspected for leaks or defects. All leakages shall be made good and all defective parts replaced such that the system passes the test to the satisfaction of the Engineer.

4E.104 EXTERNAL PLUMBING:

a) <u>Gutters, Rainwater pipes and fittings:</u>

These shall be as required by the Particular Specification and as shown on the Drawings and selected from the following:

i) Cast Iron to BS 460.
ii) Aluminium to BS 2997.
iii) Approved enameled iron pipes (for special decorative effect).
iv) Un plasticised P.V.C. Pipes to BS 3506.

b) Flashings:

Flashings shall be of the following:

i) Cold-rolled copper sheet 0.5mm thick.
ii) Lead sheet, 1.2 mm thick.
iii) Aluminium sheet 0.8 mm thick.

c) Jointing of pipes and gutters shall be as follows:

i) Cast iron gutters shall be jointed with red and white lead putty and rust proof gutter bolts. Cast iron rain water pipes shall be jointed with red and white lead putty when used externally or with tarred yarn gasking and molten lead when used internally.

ii) Aluminium gutters and pipes shall be jointed by a double welted seam without the use of solder.

iii) Enamelled iron pipes shall be jointed with tarred gasking and red lead.

iv) Unplasticized P.V.C. pipes shall be jointed with approved solvent cements or as directed. The jointing surfaces shall be thoroughly cleaned and dried before cement is applied.

d) Fixing:

All gutters, pipes, heads, offsets, shoes, etc., shall be fixed as shown on the drawings or as directed in the Particular Specification.

All gutters shall be fixed complete with all necessary angles, square and obtuse, right and left hand, external and internal. All necessary stop ends, stop and outlets, socket and spigot drops double socket clips, tees and nozzle pieces, double end nozzle pieces, double socket clips etc., shall be provided and fixed. A copper wire baloon guard shall be provided and fixed in each gutter outlet.

Gutter brackets are to be of stout metal of the same relative heavy make as the gutters. The brackets shall be of the screw-on-to-fascia type whenever possible, and shall strictly correspond with the gutters in pattern and shape. At

least one bracket shall be provided for each gutter length and shall be painted when required before fixing.

Rainwater pipes and fittings shall be fixed to the wall by approved holderbats or other means plugged and screwed to the wall. Where required, the pipes and fittings shall first be fitted then removed, to allow for painting or rough-cast finishes to be applied and they shall then be refitted and jointed.

4E.105 PIPES AND FITTINGS:

Pipes and fittings for conveying fresh water for both hot and cold services and for wastes shall be as required by the Particular Specification or as shown on the drawings and selected from the following:

a) Underground Services.

b) Solid drawn copper tubes complying with BS 2871 with capillary or compression fittings of copper alloy complying with BS 864.

ii) Galvanized, seamless steel tubes to BS 387 heavy tubes galvanized malleable cast iron fittings to BS 143.

b) Internal Services etc.

i) Solid drawn copper tubes complying with BS 2871 Table 1, Water and Gas quality, with capillary or compression fittings of copper alloy complying with BS 864.

ii) Galvanized, seamless, screwed, and socket steel tubes to BS 1387 Heavy Tubes, with galvanized malleable cast iron fittings to BS 143.

iii) Unplasticsed P.V.C. pipes shall comply with BS 3505 with compression fittings of brass and gunmetals required. Fixing brackets and clips shall be generally in accordance with British Standards. The maximum spacing thereof shall be as set out in Table 14.1 below.

TABLE (14.1). SPACING OF PIPE FIXING

Nominal Size of pipe (inches).	Spacing Horizontal Runs (cm.)	Spacing Vertical Runs (cm.)
1/2	180	240
3/4 and 1	240	300
1 1/4, 1 1/2 and 2	300	360
2 1/2 and above	360	360

4E.106 JOINTS:

Joints between pipes, fittings and drains shall be executed as detailed in Table 14.2

TABLE (14.2). JOINTS BETWEEN PIPES

Pipes.	Joints.
Copper to similar pipes:	Approved capillary of compression fittings (BS 864) fixed in accordance with manufacturer's instructions.
Copper to steel:	With approved copper to iron fittings fixed in accordance with the manufacturer's instructions.
Copper or steel to Cast Iron:	With approved caulking bushes and jointed as for cast iron to cast iron in Drain layer Section.
Copper or steel to salt-glazed ceramic:	As in Drain layer Section.
Cast iron to salt-glazed ceramic:	-Ditto-
Steel to Steel:	With BS 21, taper, thread, screwed and socket joints in lead and gasket.
Lead to Lead:	With neatly executed wiped solder joint.
Lead to other pipes:	With an approved connector with tail for lead and wiped tail for lead and wiped solder joint.
Unplasticised P.V.C. pipes:	With cemented spigot and socket with brass and gunmetal compression fittings or with flanges.

Flexible connections where specified shall be of an approved quality.

All cuts shall be made square to the pipe axis by approved means and all burrs shall be removed. The use of pipe cutting appliances which diminish the bore of the pipe shall not be permitted.

Joints between different metallic materials shall be made with suitable insulators to prevent electrolytic action.
Joints between waste pipes and lavatory basins, drinking fountains, traps of sinks, baths, showers, etc., shall be made with suitable screwed unions in the case of wrought iron or steel, by compression fittings in the case of copper, by caulked run lead joints in the case of cast iron, and by wiped soldered joints in the case of lead. In all cases provision shall be made for cleaning the traps in the event of blockages.

Wastes of sinks, lavatory basins, etc., shall be set into the appliances with white lead and secured with screw fittings.

4E.107 BRASS WORK:

Taps and stop valves shall comply with BS 1010 and shall be marked with the manufacturer's name trade mark and the nominal size.

Gate valves shall comply with BS 5154, Gate Valves for hot water systems shall be bronze parallel slide valves. Valves shall be marked with the manufacturer's name or trade mark, the nominal size and the class number.

Mixing valves shall comply with BS 1415 and shall be marked with the manufacturer's name and trade mark and the nominal size.

Traps and wastes shall comply with BS 1184. Where systems are provided with anti-syphonage, traps occurring in ranges of fittings shall have 40mm (1.5 in.) deep seals. Where no anti-syphonage is provided, such traps shall have 80 mm (3 inch) deep seals.

Flushing cisterns and flush pipes shall comply with BS 1125. Ball valves shall comply with BS 1212 and marked with the manufacturer's name or trade mark. Floats shall comply with BS 2456 and shall be marked with the manufacturer's name or trade mark. A manufacturer's certificate testifying that the flushing cisterns comply with BS 1125 must be submitted to the Engineer.

4E.108 STORAGE TANKS:

Water storage tanks shall be provided Fiber Glass, as per Kuwait Standard Specification. (K.S.S 537-1972).

4E.109 SANITARY FITTINGS:

All sanitary fittings shall be of an approved quality obtained from an approved manufacturer. Sanitary fittings and their connections, services, wastes etc., shall be located as shown on the Drawings and shall be designed and installed to the satisfaction of the Engineer.

Unless otherwise required by the Particular Specification or shown on the Drawings, the quality and sizes of the fittings shall be according to British Standard as follows:

a) Sinks shall be either white glazed fireclay complying with BS 1206 or stainless steel complying with BS 1244 fitted with two 0.5 in. diameter chromium plated bib cocks, combined overflow and 1.5 in. diameter trapped waste, plug and chain. Sinks shall be fixed on pair of cantilever brackets built into wall or on frame and supports of 1 in. diameter galvanized steel pipe or on block work piers as detailed on the drawings, or directed by the Engineer.

   All sinks shall be of the sizes shown on the Drawings or as indicated in the Particular Specification.

b) Lavatory basins shall be white enameled glazed fireclay complying with BS 1188,

size 55 x 40 cm. (22 x 16 inches) weighing approximately 20 Kg. fitted with two 0.5 in. diameter chromium plated pillar valves, combined overflow and 1.25 in. diameter trapped waste, plug and chain. Lavatory basins shall be fixed on pair of cantilever brackets built into walls.

c) Baths shall be white porcelain enameled cast iron complying with BS 1189, with rectangular tops and side and end panels where required, fitted with two 0.75 in. diameter chromium plated pillar valves, 1.25 in. overflow and 1.5 in. diameter trapped waste, plug and chain. Where baths are fitted with a shower this shall be of either the overhead type or the telephone type. In all cases the shower hose and exposed piping shall be chromium plated and the connections to such showers shall be through a chromium plated mixing valve. The baths and showers shall be fixed as detailed on the Drawings or directed by the Engineer.

d) Asiatic Water Closet Suites shall be sea-water resistant and shall comprise white glazed fireclay squatting slab, pan 'S' or 'P' trap with 3.5 inch bore outlet, two gallon capacity high or low level white enameled cast iron or white glazed fireclay or plastic flushing cistern fixed to walls with cantilever brackets or concealed fixing, 1.25 in. (high level) or 1.5 in. (low level) diameter flush pipes, non-corroding valve less syphon, 0.5 inch low-pressure ball valve and union, 0.75 in. overflow and union, and either flushing handle or pull and chain. In a position adjacent to each Asiatic Water Closet, a suitable water draw off point shall be provided. A flush valve may be installed instead of the flushing arrangement described above if required.

e) European Water Closet Suites shall comprise white glazed fireclay pan complying with BS 5503, weighing approximately 20 Kg. and having 'S' or 'P' trap with 3.5 in. bore outlet, two-gallons capacity high or low level white enameled cast iron or white glazed fireclay flushing cistern fixed to wall with cantilever brackets or concealed fixing 1.25 in. (high-level) or 1.5 in. (low level) diameter flush pipe, non- diame-corroding valve less syphon, 0.5 in. low pressure ball valve and union, 0.75 in. overflow and union, either flushing handle or pull and chain, and with double flap solid section plastic ring seat complying with BS 1254.

f) Urinals shall be either wall fitting bowl type urinals of white glazed fireclay or stall type urinals of white glazed fireclay. The bowl type shall be supported on steel brackets cut and pinned to wall and shall have chromium plated flat grating and outlet. The stall type shall comprise back slabs, division returned ends, floor treads, channel with returned ends and chromium plated removable domical grating and outlet. Flushing cisterns of sufficient capacity shall be connected through flush pipes and spare pipes of copper,. chromium plated where required.

g) Where required seawater resisting flushing shall be used.

4E.110 SUNDRIES :

The following fittings shall be provided:

a) Adjacent to European water closet a porcelain, chromium plated or white-enameled paper holder.

b) To the wall adjacent to lavatory basin a chromium plated or white enameled towel rail with end brackets.

c) Adjacent to bath a recessed porcelain soap tray, with a hand hold.

d) Mirror over wash basins of approved quality and make.

4E.111 ELECTRIC WATER HEATERS:

Thermal storage electric water heaters shall be of the low pressure thermostatically controlled type complying with BS 843 and BS 3456 Section A 13. Immersion electric heaters shall further comply with BS 3456 Section A8. Notwithstanding the stipulations of these standards specifications, thermal storage electric water heaters and their installation shall be in accordance with the regulations of the Ministry of Electricity & Water.

The water heater shall consist of an inner and outer container, thermal insulation between the containers, an immersion heater, thermostat, pipe fittings, and safety valve.

The inner container shall be minimum of heavy gauge copper sheet with double lap longitudinal and circumferential shell joints. All joints shall be brazed. The inner container shall be tinned internally and fitted with B.S.P.T. water connections.

The inner container shall withstand a pressure of 3.5 Kg /Sq.cm.

The outer container of high grade sheet steel rust proofed with two coats of anti-rust paint inside and outside, and finished in stove enamel. The space between the inner and outer containers to be padded with efficient thermal lagging.

Water heaters of up to 20 gallons capacity shall be provide with substantial lugs, for wall mounting; water heaters of greater capacity shall be floor mounted.

The immersion heater to be of the sheathed wire element, non withdraw able type, having a hexagonal flange with 1.25 inch B.S.P.T.

The regulation of the water temperature shall be by means of an adjustable thermostat of 20 amps minimum rating. The range of temperature adjustment shall be not less than 32° to 82° C (90° to 180° F).

The outer case shall be provided with a suitable entry for 0.75 inch or 1 inch electric conduit for the electric connections.

Water heaters of up to 20 gallons capacity shall be suitable for operation from a 240 Volt 50 c.p.s. electrical supply; heaters of greater capacity shall be suitable for operating from a 415 Volt, 3 phase 4 wire 50 c.p.s. electric supply.

4E.112 BUILDER'S WORK:

Where pipes are fixed on the surface of walls the contractor shall perform all cutting and pinning for holder bats or plugging and screwing for pipe clips. Where pipes are concealed in the walls etc., the Contractor shall perform all cutting and subsequent making good. Pipes through walls or floors shall pass through metal sleeves and covers shall be provided at points of emergency. All builder's work by the plumber shall be finished in a neat and workmanlike fashion and to the satisfaction of the Engineer.

4E.113 TESTING:

When the installation has been completed to the satisfaction of the Engineer it shall be tested in the following manner:

a) The entire system of hot and cold, brackish and fresh water shall be slowly filled with water, allowing any trapped air to escape.

b) All outlets shall then be closed and the systems checked for water tightness.

c) A test pressure of 10 atmospheres shall be applied to each. The entire system at points selected by the Engineer and retained for a period of at least 48 hours. The entire system shall then be checked for leaks and defects.

d) Finally, after the test pressure is released, each outlet shall then be checked for rate of flow and correct operation.

The Contractor shall provide all facilities for the testing and make good any defects to the satisfaction of the Engineer.

4E.114 CLEANING:

The Contractor shall carefully clean out all cold water and hot water tanks, service pipes, sanitary fittings throughout, traps, and wastes. The Contractor shall also overhaul and make good all flushing valves, check regulating valves, check taps

including rewash ring as necessary, and leave all works in perfectly clean and working condition.

GLAZIER

4E.115 GENERAL:

The type of materials and nominal thickness of glasses shall be as shown on the Drawings.

The Contractor shall replace all cracked or broken glass and clean all glazing on both sides and all mirrors prior to handing over.

4E.116 GLASS:

All glass shall be first quality and of an approved type and make. The Contractor shall submit samples of all glass to be used on the Works to the Engineer for approval.

The types and quality of glass used shall not in any case be inferior to the following:

a)Clear sheet glass, as follows:

TABLE (15.1). CLEAR SHEET CLASS

Limit of Thickness (mm)	Approximate weight (Kg/sq.m.)
2.75 - 3.05	7
3.10 - 3.50	8
3.90 - 4.30	9
4.65 - 5.25	11
5.30 - 5.80	14
6.25 - 6.75	16

b) Clear plate glass, as follows:

TABLE (15.2). CLEAR PLATE CLASS

Limits of Thickness (mm)	Approximate Weight (Kg/sq.m.)
3.97 - 5.56	11
5.56 - 7.94	15
9.13 - 10.72	23
11.91 - 13.49	30
18.25 - 19.82	45

c) Clear float glass, where required, shall be 6 mm thick and of an approved make.

d) Translucent glass, as follows:

TABLE (15.3). TRANSLUCENT GLASS.

Limits of Thickness (mm)	Approximate Weight (Kg/sq.m)
2.90 - 3.50	8
4.50 - 5.15	11
6.35 - 7.00	16

e) Translucent absorbent and insulating glass where required shall be as specified in the Particular Specification.

f) Wire glass shall be either wired cast glass or polished wired cast glass with 12.5 mm square wire mesh 0.5mm hexagonal wire mesh 0.5mm in diameter, as called for the Particular Specification or as shown on the Drawings and as follows:

TABLE (15.4). WIRED GLASS

Type	Limit of Thickness (mm)	Approximate Weight (Kg/sq. mm)
Rough Cast (Square mesh)	6.30 - 6.60	16
Polished (Square mesh)	5.90 - 6.10	16
Rough Cast (Hexagonal mesh)	5.90 - 6.10	16

g) Heat absorbing plate glass, either (a) 70% Light Transmission or (b) 55-60% Light Transmission with 75% Restriction of Solar Radiation, or as called for in Particular Specification or as shown on the Drawings and as follows:

TABLE (15.5). HEAT - ABSORBING PLATE GLASS

Limit of Thickness (mm)	Normal Thickness (in)	Approximate Weight (Kg/sq.m.)
4.0 - 6.0	3/16	11
5.5 - 7.5	1/4	16

h) Mirror glass shall be silvering quality polished plate glass silvered on one side, copper-backed varnished and painted to the satisfaction of the Engineer. Edges or mirrors shall be leveled.

4E.117 OTHER MATERIALS:

a) Putty for glazing to wood other than non-absorbent hardwoods shall be tropical grade wood glazing.

b) Putty for glazing to metal and non-absorbent hardwoods shall be tropical grade metallic glazing.

c) Wood glazing beads shall be of the same timber as the frame and shall be splayed and rounded to the sizes shown on the Drawings and neatly mitered and braded.

d) Metal glazing beads shall be supplied with metal windows, doors and partitions and shall be sprung or screwed on as shown on the Drawings or according to the manufacturer's instructions.

4E.118 WORKMANSHIP:

a) Glazing to Wood Without Beads:
The rebates shall be previously treated with one coat of priming paint and the bedding putty inserted. The glass shall be embedded in the putty and secured by springs. The front putty shall be inserted to form a triangular mitred filling from the edge of the rebate to 2 mm back from the sight line. The bedding putty shall be trimmed off level with the sight line to form a neat back putty. When the putty has hardened sufficiently the painting shall be carried out and care shall be taken to seal the joint between putty and glass by painting to the sight line.

b) Glazing to Wood with Beads:
The rebates shall be previously treated with one coat of priming paint and the bedding putty inserted. The glass shall be embedded in the putty and secured by the beads. The bedding putty shall be trimmed off level with the sight line to form a neat back putty and the painting shall be carried out.

c) Glazing to Metal:
Only glazing to metal with beads shall be permitted. The rebates shall be previously treated either by rust proofing or priming as described elsewhere, and the bedding putty inserted. The bedding putty shall be trimmed off level with the sight line to form neat back putty and painting shall be carried out.

d) Glazing without putty:
Where specified, wash leather, ribbon velvet, flannel, felt, asbestos, rubber, plastics, or similar materials shall be used in place of putty for internal glazing in conjunction with beads. The materials should be so fitted as to cover all parts of the glass which will be covered by the rebate and bead. The manufacturer's instructions shall be followed to the satisfaction of the Engineer.

e) Fixing of Mirrors:
Mirrors shall be fixed to walls with rubber sleeves and chromium-plated dome-

headed screws driven into plugs prepared in walls.

PAINTER

4E.119 GENERAL:

The Contractor shall provide all labour, materials, scaffolding, tools and implements required for preparation of surfaces, application of paint, making good any defect and cleaning of any paint splashes to other works.

All materials shall be obtained from manufacturers approved by the Engineer and shall be supplied to site in the manufacturer's sealed and branded containers. Samples of materials proposed by the Contractor shall be submitted as soon as possible after signing the contract, to the Engineer who shall have the right to request tests to be conducted on site or in the Kuwait Government Research Laboratory or other approved laboratory prior to approving such materials for use on the Works.
The mixing of materials of different brands before or during application shall not be permitted. Brushes, pails, kettles and other implements or tools used in painting or reparation of work shall be clean and free from foreign matter. They shall also be cleaned thoroughly before being used for different types or classes of material or colors.

4E.120 DEFINITIONS:

Alkyd: Synthetic resins of great versatility, used as the basis of high quality paints, enamels and stowing finishes. For building and decorative paints they contain a high proportion of drying oil ("long-oil" alkyds) and harden by oxidation.

Base:
a) A term used to indicate the major or characteristic ingredient in a particular paint, e.g. lead base, oil base.

b) Used to denote the ground or substrata which is to be painted.

Binder: The non-volatile part of a paint vehicle which on drying binds the particles of pigment together to form a coherent film. Example, linseed oil, alkyd resin, polyvinyl acetate.

Emulsion: A suspension of very small droplets of an oil, resin, bitumen or other liquid in water, usually brought about or stabilized by the aid of a third component called an emulsifying agent.

Emulsion Paint: A paint in which the vehicle is emulsified in water. The term is usually applied to paints in which the dispersed binder is a synthetic polymer.

Enamel: A paint with superior qualities of hardness gloss and flow.

Epoxy Resin: A synthetic resin containing a chemical grouping (the epoxy group) conferring the ability to form coatings by various hardening (drying) mechanisms.

Filler: A liquid or paste composition suitable for filling pores, cracks, joints, and blemishes in surfaces, applied by brush or knife.

Finish: a) (Finishing Coat) the final coat of a painting system.
b) The general appearance of a painted surface.

Knotting: Usually a solution of shellac or similar for sealing the resinous exudation from knots in timber. An alternative type of composition contains flake aluminum.

Lacquer: Strictly a coating which dries to a hard, generally glossy, surface without the absorption of oxygen, drying is purely by the evaporation of the solvent in which the resinous binder is dissolved. Lacquers may be clear, pigmented or transparently colored.

Medium: The liquid portion of paint that carries the pigment, composed of the binder and solvent or thinner. (Synonymous with 'Vehicle' in the liquid paint, and with 'binder' in the dry film).

Oleoresinous: A term applied to media composed of oils and natural (or modified natural) resins, usually in contrast to alkyd and synthetic resin media.

Paint: A suspension of finely divided solid pigment in an oil or varnish which is applied to a surface as a liquid and becomes converted to a solid film. (The terms is used in a general sense to include lacquers and enamels).

Pertifying Liquid: Usually an emulsion of oil or oleo resinous binder added to a distemper to confer extra durability or easier application on absorbent surfaces, or applied as a sealing coat.

Pigment: A finely divided insoluble powder acting as coloring matter, the term also includes extenders or 'fillers' which have little or no coloring or opacity action.

Primer: The first coat of a paint system used on a specific surface to provide

adhesion, satisfy absorption or prevent corrosion. Not to be confused with undercoat.

Sealer: a clear or pigmented composition used to prevent excessive suction of porous surfaces or to prevent soluble matter or alkali in the surface from bleeding into or affecting subsequent coats.

Solvent: A volatile liquid used to dissolve the binder or resinous component, and lost from the film by evaporation during drying.

Stopping (Stopper): A stiff paste composition used for filling holes and crevices before painting.

Thinner: A volatile solvent used to reduce the viscosity of paints or paint vehicles to the correct degree for application. Water is the thinner in emulsion paints.

Undercoat: The coat(s) intermediate between primer (or existing paint) and finishing coat. Not to be confused with 'Primer'.

Vehicle: The liquid portion of a paint in which the solid pigment is dispersed.

4E.121 WORKMANSHIP:

No exterior or exposed painting shall be carried out under adverse weather conditions such as rain, extreme humidity, dust storms etc.,

Painting work shall preferably be shaded from direct sunlight to avoid blistering and wrinkling. Wherever possible, painting of exterior surfaces shall 'follow' the sun such that it is carried out in shadow.

Every possible precaution shall be taken by the Contractor to keep down dust during the painting process or preparation therefore, including as necessary the cleaning of each room beforehand and the dampening of floors.

Prepared, primed or undercoated work shall not be left exposed or in an unsuitable condition for an undue period before completion of the painting process.

Metal or other fittings such as ironmongery etc. not required to be painted shall first be fitted and then removed before the preparatory process is commenced. When all painting has been completed the fittings shall be cleaned and re fixed in position.

No paint shall be applied to work which is internally or superficially damp.

All surfaces shall be free of loose matter, efflorescence, dust, etc., before the application of each coat.

Paints shall be stirred in their original container until smooth to before use.

Thinning or dilution of paints shall be in strict accordance with the recommendations of the manufacturer in each case.
The first set of brush strokes for any coat shall be crossed (vertical and horizontal) after which such coat shall be finished with a light stroke either vertical or parallel to the gain in the case of timber.

In addition to the general stipulation above, workmanship for different classes of work shall be as follows:

a) Iron and Steel:
Surfaces shall be thoroughly cleaned to remove grease and dirt and wire brushes and scraped to remove scale and rust. If found necessary by the Engineer a de scaling pistol with steel needles with pointed or chiseled ends shall be used.

A minimum of two coats of primer shall then be applied by brushing well into the surface.

Each coat shall be allowed to dry and harden thoroughly before the next coat is applied.

Where a surface is to be finished in light colored oil or gloss paint, one or more coats of undercoat paint are to be applied until sufficient cover is obtained to the satisfaction of the Engineer.

Finishing shall be a minimum of two coats of paint and until sufficient cover is obtained to the satisfaction of the Engineer. They shall be applied by brushing whether an undercoat is used or not.

b) Non-Ferrous Metals:
Galvanized steel surfaces shall be cleaned thoroughly by scrubbing with thinners or solvents and any rust removed as for iron and steel above. Two coats of primer shall then be brushed on. Undercoating and finishing shall be as for iron and steel above.

Where aluminum is required to be painted it shall be thoroughly cleaned by swabbing with neutral detergent or solvents, roughened by use of abrasive paper or powder and further cleaned by washing two coats of zinc chromate primer

shall be brushed on (Red or White lead primers shall not be permitted). Undercoating and finishing shall be as for iron and steel above.

Where copper or brass surfaces are required to be painted they shall be thoroughly cleaned by swabbing with thinners or solvents and roughened with fine abrasive paper followed by washing. Priming shall be with aluminum primer. Undercoating and finishing shall be as for iron and steel above.

c) Wood.

Wood surfaces shall be sanded to a fresh surface. Surface mould where present shall be removed by washing, rubbing down and burning off as necessary. Oily timbers shall be swabbed with white spirit. Resinous exudation and large knots shall be removed and replaced with filler or knotty.

Parts of timber to be enclosed in walls shall always be primed unless already impregnated. Priming shall be brushed on and a minimum of two coats applied to end grain. When the priming paint is hard, all cracks, holes, open joints, etc., shall be made good with hard stopping and rubbed down with fine abrasive paper. Priming of joinery shall be applied only on site after the Engineer has approved such joinery and before it is fixed. For internal surfaces primer coats shall be carefully flatted.

d) Concrete, Cement Block, Cement Plaster and Rendering.

Such works shall be allowed to dry out completely before carrying out painting operations. Plaster applied in the winter months (October to April) shall be at least ten weeks old and that applied in the summer months (May to September) shall be at least five weeks old before commencing painting operation.

Painting shall not be permitted when the relative humidity of the atmosphere exceeds 70%. Preparation of surface shall consist of vigorous brushing and rubbing down to remove loose surface material and dust. Surfaces should then be left for a week to determine whether efflorescence reappears in which case it shall be brushed off dry and a further waiting period of one week allowed. No painting shall be carried out until the Engineer is satisfied that no efflorescence is occurring.

Cracks shall be made good, internally using plaster or a filler and emulsion paint and externally using plaster or sand / cement mortar as applicable, except that the use of sand - cement mortar on fair-faced concrete is not permitted without the prior approval of the Engineer. Where directed by the Engineer rough work and porous patches shall also be made good as above. If extensive making good is required, the Contractor shall at his own expense apply a thin coat of primer overall. Such patches or repair work shall be allowed to dry out completely

before proceeding further.

Wherever required, one or two coats of 'alkali-resistant' primer shall be applied, sufficiently thinned to penetrate the surface, to provide alkali resistance and act as filler or sealer.

The use of lime wash for priming or filling and sealing shall not be permitted.

Finishing shall be a minimum of two coats and until sufficient cover is obtained to the satisfaction of the Engineer. Finishing coats may be applied by either brushing or rolling.

Where cement-based paint is used precautions shall be taken to prevent drying out before hydration of the cement is complete including as necessary pre-wetting of the surface, working out of direct sunlight and re-wetting of the surface, working out of direct sunlight and re-wetting before re-coating. Cement-base paints shall be applied by brush or trowel in accordance with the manufacturer's instructions.

In parts of buildings subjected to high humidity or condensation conditions such as kitchens and bathrooms emulsion paints shall not be permitted and only water-resistant finishes shall be used.

The finishing coat of paint shall only be applied after all other works likely to damage or discolor paint work has been completed.

e) Soft boards and Hardboards:
Surfaces shall be clean of loose material and dirt.

A sealing coat of primer or of shellac knotting thinned with its volume of methylated spirits shall be applied to all highly absorbent boards and in any case to boards to be finished with oil-based paints.

Where emulsion paints are to be used on soft-boards, the sealing coat may be dispensed with by application of three coats in quick succession, the first-coat of which is thinned with an equal volume water.

Where pre sealed hard-board is used, no primer or sealer coat is necessary.

Finishing with or without undercoating shall be as for wood, (c) above.

f) Acoustic Tiles:
Surfaces shall be free of dust and preferably painted by spraying if so required.

Only very thin coats of emulsion paint or distemper shall be used and the number of coats shall be the minimum required to give adequate cover to the satisfaction of the Engineer.

h) Acoustic - Cement:
Surfaces shall be thoroughly cleaned of dirt and dust.

Where emulsion, chlorinated rubber or cement based finishes are to be used no primer is required. Where a paint finish is required which is not itself alkali-resistant, two coats of alkali resistant primer shall be brushed on.

Impermeable paint finishes shall only be used if the concealed side(s) of the asbestos-cement pipe or gutter, etc., is also made impermeable to moisture. Where this is to be done on Site, bituminous paint or two coats of alkali-resistant primer shall be used for surfaces invisible after fixing.

Exposed surfaces shall be finished as required by the Engineer.

4E.122 MATERIALS:

Colors shall be required by the Particular Specification or shown on the Drawings, designated by the appropriate numbers of BS 4800.

The materials to be used shall be of an approved type and make and as required by the Particular Specification or shown on the Drawings, selected from the following:

a) Wood primer, for use on soft and non-oily hardwoods.

b) Wood primer, aluminum base for use on all woods.

c) Iron and steel primer lead-based.

d) Zinc and steel primer.

e) Aluminum primer, zinc chromate-base, containing not less than 40% zinc chromate in the pigment.

f) Concrete, plaster and rendering primer, alkali-resistant, based on a non-saponifiable medium.

g) Undercoat for oil gloss finish.

h) Undercoats for other finishes, in accordance with the recommendations of manufacturers of approved finishes.

i) Oil gloss exterior finishes.
j) Oil gloss finishes, zinc oxide base.

k) Other gloss finishes, including 'hand-gloss', 'high-gloss', 'gloss-enamel' and 'alkyd' finishes.

l) Oil-bound water paint.

m) Chlorinated rubber paint,

n) Cement paint.

o) Emulsion paint.

p) Knotting compounds.

q) Thickness shall be approved turpentine or white spirit or in strict accordance with the manufacturer's recommendations where it is to be mixed with paint.

r) Resinous paint 'non-poisonous' quality.

4E.123 APPROVAL OF MATERIALS AND TESTING:

The Ministry will from time to time issue an up-to-date list of approved paint materials which have given satisfactory service in Kuwait.

Contractors may propose that new paint materials should be added to this list. Such requests shall be accompanied at sufficient quality for testing at the Kuwait Government Research Station or by a certificate issued by an approved independent laboratory or certificate issued by an approved independent laboratory or certifying agency in the manufacturer's country of origin to the effect that the following tests have been conducted on a comparative basis with an already approved type and make and the results are at least equivalent. A full description of the method of sampling, specific references to test methods used, and all test results shall be submitted with each certificate.

The tests called for are the following where applicable:

a) Salt-Spray (Fog) testing, to ASTM H 117, the time exposure being at least such as to cause failure of the approved specimen. Comparative evaluation shall be to ASTM D 1654, "Evaluation of painted or coated specimens subjected to corrosive environments".

The test panels to be used shall be of the same material as those of the metallic surfaces on which the paint submitted for approval is to be used.

b) Light and water exposure testing to ASTM D 822, the time of exposure being at least such as to cause changes in the approved specimen which can be evaluated as given by ASTM D 822, paragraph 4, "Evaluation of Results". For bituminous materials, ASTM D 529 is to be used. The apparatus and its operation shall be as described in ASTM - E 42.

c) Adhesion of coating test, to ASTM - D 2197, the test panels used being of the same materials as those of the surfaces on which the paint submitted for approval is to be used.

d) Abrasion Resistance Test, to ASTM - D 968, using steel panels.

e) Relative dry hiding power test, to ASTM - D 344.

f) Efflorescence of Interior Latex-Paints, to ASTM - D 1736.

g) Test panels and preparation thereof shall be as called for in the relevant ASTM Standard.

4E.124 ROADS GENERALLY:

All roads shall be constructed generally in accordance with Section I, II, III, IV and X of the Technical General Specification for roads and Drainage of the Government of Kuwait 'Ministry of Public Works' (Roads and Drainage Department).

The following qualifications to the Technical General Specification shall apply;

1) Clause 200.18 Rollers of all types shall be rating B. Clause 301.04 Gradation C shall apply. Clause 302.03 Sand Asphalt shall be type A. Clause 401.03 Asphaltic concrete wearing course shall be type III. Clause 405.01 Seal coat shall be medium aggregate seal coat.
2) The widths, cross falls and thickness of construction of roads and hard-standings shall be as shown on the Drawings.

The Contractor is reminded to have available on the site for reference a copy of the MPW Specification.

4E.125 INTERNAL ROADS (TECHNICAL SPECIFICATION):

1) All the works to be executed according to M.P.W. Roads & Drainage department specification, a copy could be obtained from the Ministry of Public Works.
2) Any stored materials that may obstruct the roads works, the Contractor should transport them by his own equipment and labor in a proper way and to be stacked in another location in the store away from the road works. Therefore

the Tenderer should inspect the Site before tendering and to include that works in his rates.

3) Any surplus materials from excavating should be transported outside the working area his rates should include for that.

4E.126 INSULATION OF WALLS AND ROOFS:

The insulation of walls and roofs shall be in accordance with the Ministry of Electricity and Water Specification.

4E.127 SURFACE BOXES:

Surface boxes shall include a cast iron heavy duty cover and frame and be suitable for wheel loads up to 11.43 tons. Surface boxes shall be coated by dipping or other equivalent means using a hot applied coal tar based material complying with BS 4164 or a cold applied black bitumen material complying with BS 3416. No coating shall be applied to any casting until its surfaces are clean, dry, and free from rust, oil, and deleterious material.

END OF THIS SECTION

GOVERNMENT OF KUWAIT

MINISTRY OF ELECTRICITY AND WATER

CONSTRUCTION AND MAINTENANCE OF 5 NOS. R.C. GROUND RESERVOIRS FOR FRESH WATER, 55 M.I.G CAPACITY EACH, AND ANNEXED WORKS AT MUTLA HIGH (STAGE-II)

SECTION – 4F

TECHNICAL SPECIFICATION FOR

CHLORINE DIOXIDE PLANT

4F.01 GENERAL SPECIFICATION FOR CHLORINE DIOXIDE GENERATING SYSTEM

CONTENTS

CHLORINE DI-OXIDE PLANT - GENERAL SPECIFICATION

(1.0.)CHLORINE DI-OXIDE PLANT

(1.1.)GENERAL

The Contractor shall design, supply and install the complete chlorine di-oxide system for all chemical equipments including:

(1)Chemical storage tanks , chemical loading pumps ,motive water mps, ejector, chlorine di-oxide solution preparation system(Generators),the water supply system, flushing and drainage systems, pumps and fittings, together with the system of administering the chemicals to the points of application.

The system shall be complete with Air conditioning &ventilation equipment, chemical handling, safety equipment and all other accessories specified and required to provide a comprehensive chlorine di-oxide plant in all respects.

In the layout of the plant adequate space shall be provided for access to carry out operations and maintenance of equipment.

(2) Motive water supply lines should be D.I pipes, Chlorine dioxide solution lines &sampling lines should be CPVC, water take-off lines should be (CPVC& D.I),inside R.C trenches with proper support R.C trenches removable covers should be hot-dip-galvanised iron plates with hooks.

All chemical injection, motive water system, chlorine di-oxide system, sampling, lines shall be provided with indication for all in/out arrow sign with colours.

(1.2.)CHEMICAL PLANT SAFETY

The Contractor shall design the plant to a high standard of safety and shall comply with all local statutory requirements and where such local standards do not exist those of any other relevant bodies recognised or applied locally unless otherwise specified.

The chemical storage and handling plant shall confirm to the relevant technical service notes and literature published by the potential chemical suppliers and plant manufacturers and any other guidelines published by reputable authorities.

The Contractor shall obtain the approval of the chemical supplier for the design of the reception and storage facilities before proceeding with installation. In the case of toxic or hazardous chemicals the Contractor shall afford the suppliers the opportunity of offering advice on safety precautions to be taken on the design layout, operation and maintenance of the plant.

Safety signs shall use local or internationally recognised pictorial representations, such as those in BS 5378 and BS 5499 and Health Safety (Safety Signs & Signals) Regulations, 1996, SI 1996/0341, HMSO, UK.

Signs shall be manufactured from durable, non-fading, and weather resistant materials. Materials shall be of durable quality and chemical resistant for their intended environment, and suitable for both indoor and outdoor use. Signs shall be in stove enamelled aluminium with rounded corners and drilled fixing holes as specified.

Chemical supplier's notices shall be framed with Perspex cover and a suitable backing board and mounted either on a clear wall just inside the access door or adjacent to plant as appropriate.

Drawings of all warning signs and notices shall be submitted to the Engineer for approval.

(1.3.)PIPEWORK

Pipe-work materials for chemicals shall be selected with due regard to chemical compatibility, location, environmental conditions and operating regimes.

Pipe-work material requirements for individual chemicals are set in the specification for each chemical.

In the case of pipe-work located outdoors, particular consideration shall be given to the effects of ultra-violet rays, temperature and impact by wind-blown objects. Thermoplastic materials shall not be painted as a means of protection but shall be shielded from direct sunlight and adequately guarded against mechanical damage.

Where pressure and temperature de-rating precludes the use of thermoplastics, suitably lined reinforced plastics, rubber lined carbon steel or stainless steel shall be used. Stainless steels shall not be used for chemicals containing chlorides.

Unless otherwise specified all external chemical pipe-work shall be laid in trenches provided with removable covers.

All pipe-work and hoses in trenches shall be adequately supported throughout their run. Pipes shall be fixed to walls or mounted on channel sections fixed to walls or on cantilevered supports off walls. Hanger type supports shall not be acceptable nor shall pipes be underslung from roofs or cantilevered supports or supported on the underside of pipe supports.

Pipe-work laid on the floor of trenches shall be supported on channel sections or similar off the floor.

Pipe-work shall be supported in accordance with manufacturer's recommendations and adequate provision shall be made for thermal expansion and contraction. Supports shall not be positioned in close proximity to fittings that would interfere with the natural movement of the pipes. Supports shall be sufficiently wide to offer adequate bearing surface and shall be installed so as to offer lateral restraint without restricting axial movement of the pipe.

Valves and other devices shall be supported independently of the pipe.

Fixings of pipes shall by clips (cobra type) or clamps. Where clamps are used on plastic pipes, pipe cushioning shall be used and the pipe shall be mounted on channel sections with a plastic strip in between.

All pipe supports in chambers and below ground level shall be stainless steel to BS970 grade 316. Elsewhere supports shall be hot dipped galvanised.

Hoses carrying chemical solutions shall be laid on horizontally mounted trays. Hoses shall be securely fixed to trays by clips or similar.

Hoses and pipes shall be laid in such a way that individual pipe/hoses can be removed without dismantling adjacent pipes/hoses.

The racks or trays used to carry chemical pipes/hoses and water service pipes shall not be used for conveying electrical/instrument cable. Where electric/instrument cables are laid in the same trench or gallery with chemical/water pipes the electric/instrument cables shall be laid on uppermost trays.

For pipe-work laid in ducts, the number of pipelines per duct shall be limited to one for pipelines with solvent welded joints and three for pipelines with butt fusion welded joints. For single pipes, the diameter of the duct shall be not less than twice the diameter of the pipe or 100mm whichever is the greater. For multiple pipes, the diameter of the duct shall be not less than 3.5 times the diameter of the largest pipe. The ducts shall be provided with draw-pits spaced at not more than 50m intervals and at each change of direction. The ducts shall be of thermoplastic construction.

Particular attention shall be paid to the layout of the chemical pipe-work, which shall be functional and neat in appearance.

All pipe-work above access ways shall be at not less than 2.5m above floor level. Pipes laid at or near floor level across access ways shall be suitably protected from damage. Joints in pipelines and fittings shall be sited away from access ways and working areas; where this is unavoidable anti-splash guards over the joints shall be provided.

Pipe-work at pumps shall be rigid and well supported so that strain is not placed on pumps. Suction pipes shall, where possible, be straight and short.

Elbows shall be avoided in pipe-work as far as possible and shall be replaced by 45 degree or long sweep 90 degree fittings.

Pipe-work shall be provided with flushing connections and drains to facilitate cleaning of pipes/hoses and fittings.

It shall be possible to isolate sections of pipe-work for flushing with minimum of interruption to dosing. Unless otherwise specified all dosing pipes/hoses and associated injection/diffuser fittings shall be provided in duplicate (1 duty, 1 standby).

All nuts, bolts, washers and screws shall be manufactured from stainless steel as set out in the Specification.

Unless otherwise specified, flanges for steel pipe-work shall be of the weld neck type, Code 111 to BS 4504 Section 3.1 with the appropriate pressure designation but not less than PN10.

(1.4.)CENTRIFUGAL PUMPS:

1. The critical speed of the pumps shall be well away from the operating speed and in no case less than 130% of the rated capacity.
2. The pumps shall have stable head Vs. capacity characteristic continuous rising towards shut-off with an approximate shut-off head of 15% more than the design head for radial flow type pumps.
3. Pumps shall be provided with non-return valve & shut off valve on discharge side and shut-off valve on suction side.
4. Unfiltered vibration velocity for horizontal pumps up to 3000 rpm with antifriction bearing or sleeve bearings when measured at the bearing housing in horizontal or vertical direction shall not exceed 4 mm/sec RMS.
5. Maximum BkW including the tolerances shall be indicated for guarantee purpose.
6. Pressure gauges shall be provided on discharge side of all pumps.
7. Each pump suction and discharge shall be installed with an expansion bellow.
8. The pumps shall be designed for continuous operation at its best efficiency to satisfy the performance requirements.
9. The pumps shall be controlled from remote panel and locally.

(1.5.)ClO_2DOSING PUMPS

a) General

Metering pumps shall be mounted in a bund and shall be fully accessible for operating purposes.

Metering pumps shall be provided with facilities for flushing and drains. A duty/standby group of metering pumps shall be provided with one calibration tube on the pump suction.

The pumps shall be of the reciprocating hydraulically actuated diaphragm type driven by electric motors. The pump, motor and drive arrangement shall be mounted on a robust combination base plate. Unless otherwise specified, only one liquid end shall be driven by any motor.

b) Pump Head Materials

Pump heads and diaphragms shall be manufactured from thermoplastic materials suitable for the duty conditions.

c) Pump Stroke Adjustable

Stroking speed of the pump shall not exceed 120 strokes per minute.

Variable stroke mechanisms shall be incorporated in the drive arrangement to allow infinity variable adjustment of pump output by means of a micrometer, hand wheel or similar mechanical device whilst the pump is running.

Where the pump is part of an automatic coagulation control or other process control loop, the stroke mechanism shall be fitted with a three phase bi-directional motor with torque limiter and automatic stops at both extremes of travel. A position feedback potentiometer shall be provided to facilitate control and remote indication of position. The operational range of stroke adjustment shall be not less than 6:1.

(d) Drive Arrangement

The pump head shall be driven through a totally enclosed speed reduction gearbox with integral reciprocating drive device of the adjustable crank or mechanical lost motion type. The gearbox and reciprocating drive shall be oil bath lubricated. The unit shall incorporated filling and drain plugs for oil and an oil level indicator.

(e) Drive Motor

Drive motor shall be the three phase cage induction type whether for fixed speed or variable speed operation.

Where variable speed operation is specified, the speed turn-down shall be not less than 5:1

(f) Pump Performance

The performance characteristics of the metering pumps shall be adequate in terms of linearity, accuracy & reproducibility as defined in API standard 675 to achieve the stated plant performance guarantee. The deviation from flow linearity of the pump shall not exceed +/- 3% of the rated capacity. The steady state accuracy shall not exceed +/-1% of the mean turndown range.

(g) Metering Pump Calibration Tube

Means shall be provided of checking the volumetric capacity of each pump in-situ including a valved branch on the suction side of the pump and a calibrated transparent tube in a support.

Calibration tube shall be transparent and of material resistant to the chemical and not discoloured by the chemical.

The effective height of the tube shall not less than 1.25m and the diameter shall be selected to ensure that at the maximum pumping capacity the rate of fall of level in the tube shall not be greater than 1.0/min. the height of the tube shall be such that when full, the liquid level in the calibration tube shall be the same as that in the stock tank. This may be achieved by providing the calibration tube with a vent pipe.

The calibration tube shall be provided with a drain discharging to an appropriate bunded area.

(1.6.)COMMON REQUIREMENTS:

1. Only latest revision of standards shall be used.
2. The tanks coming in contact with corrosive fluids should be compatible for the chemicals.
3. All the rotating equipment noise level shall be < 85dBA measured at 1 m distance from the equipment.
4. Sampling connections and air vent at the top most point of piping and vessels shall be provided at all stages of the Unit.
5. The size of the overflow pipes of all storage tanks shall be one size higher than inlet pipe sizes of these tanks.
6. All the piping & valves are to be located to facilitate easy accessibility and operation from the ground level.
7. All flange fasteners shall be GI MOC.
8. The fasteners shall be of stud type with spring washers & nuts.
9. The direction of Flow shall be indicated by an arrow at regular intervals on all pipelines.

(1.7.)VALVES

(1.7.1.)DESIGN AND CONSTRUCTION FEATURES

The following consideration shall be made during the design / selection of valves for theClO_2 System.

1. Butterfly valves shall be used for isolation / regulation purpose.
2. The material of construction for the valves shall be as per the table no 4.6.2given below.
3. The end connection for the diaphragm valves shall be of flanged type as per **ANSI B16.5, #150**.
4. Pressure rating of valves shall be of minimum PN16
5. Necessary pneumatic actuated valves shall be provided for auto operation of the plant as per the P & I diagram.
6. The painting shall be as per the requirements indicated in the painting specification.

7. Bidder shall furnish the valves schedule in the attached format. (Annexure-4)

8. Cast steel valves shall be provided for compressed air system.

(1.7.2.)VALVE – MATERIALS

Sl. No	Service	Valve Type	Size	BODY	Disc / Ball / Diaphragm	Stem / Shaft	Valve seat/ Seat ring	Pressure rating	Valve Ends
1	Dilution water line	Butterfly Valve	>65NB	ASTM A 216 GR.WCB	SS316	SS410	EPDM	#150	Wafer type
		Check Valve	>65NB	ASTM A 216 GR.WCB	SS410	-	EPDM	#150	Flanged
2	Chemical dosing Lines(Acid, Sodium chlorite, chlorine dioxide etc.,)	CPVC Ball Valve (sch 80)	All size	CPVC	CPVC	CPVC	PTFE	PN16	Solvent cement Socket End
		CPVC Ball Check Valve (sch 80)	All size	CPVC	CPVC	-	EPDM	PN16	Solvent cement Socket End
3	Compressed air application	Ball Valve	<50 NB	Galvanized cast carbon steel or Forged carbon steel	Stainless Steel / ANSI 420	Stainless Steel / ANSI 420	Nitrile Rubber / PTFE	#150	Flanged End / Screwed

(1.8.)Field Transmitters/ Meter Electronics

Field transmitters for flow, pressure, differential pressure, level, ClO_2 gas detector or density indicator transmitter shall be yoke mounted type unless specified otherwise. Meter electronics is used for flow measurement for inline meter, level measurement, analysers, etc. and shall include all the associated items like pre-amplifier, converter, transmitter, integrator, integral output meter etc.

Field transmitter shall be intrinsically safe and meter electronics shall be intrinsically safe, in general. In case, intrinsically safe is not available from the approved vendor listen closed with this FEED, flameproof enclosure is acceptable. In case sensor/ pick up coil are intrinsically safe, suitable barrier shall be provided and installed in flameproof enclosure. These transmitters shall be 2 wire systems having 4 - 20 mA DC output with superimposed digital signal having simultaneous analog and digital communication with HART communication protocol, unless otherwise specified.

The transmitter shall be microprocessor based and it shall incorporate a non-volatile memory which shall store complete configuration data of transmitter and sensor characterization. All necessary signal conversions, including conversion to produce output with the required protocol shall be carried out in the transmitter electronics. The configurationally data of the instruments shall be stored in a non-volatile memory such that this remains unchanged because of power fluctuations or power off condition. In case vendor standard instrument has battery backed RAM, Vendor to ensure that battery drain alarm is provided as diagnostic maintenance message.

(1.8.1.)Pressure Instruments (Pressure Gauges)

a) Pressure gauges shall be weatherproof to IP 55 as per IEC 60529 / IS 13947, as a minimum, with dial size of 150 mm and shall have screwed bezels. Pressure gauge sensing element shall be an elastic element like bourdon tube, bellow, diaphragm etc. ofSS316 and movement of Stainless steel, as a minimum. The design of pressure gauges shall confirm to IS-3624. Case material shall be SS304 and vapor-tight.

b) Dial markings and dial color shall be as per IS 3624. The pointer stops shall be provided at both ends of the scale to restrict the pointer motion beyond 5% above the have external micrometer adjustment for gauge zero adjustment.

c) Unless otherwise specified, the accuracy including repeatability and hysteresis shall be±1% of full scale for direct pressure gauges, ±2% of full scale for Chemical seal type pressure gauges and for Differential pressure gauges.

d) Whenever the maximum pressure specified in the data sheet exceeds the over range protection pressure, over range protector shall be provided. In case of pressure gauges with diaphragm seal, same shall be installed between the seal and the gauge.

Snubbers/pulsation dampners /gauge sever of SS304 shall be used for all pulsating services. These shall be floating pin type, externally mounted and externally adjustable. Over range protector and Snubbers, whenever used, shall be same as socket material, as a minimum.

e) Where vibrations and pressure fluctuations are expected, Glycerin filled type shall be used. In case of vibrating services like pump outlets, flexible armored hoses shall be used in place of impulse piping and gauges shall be mounted on separate stanchions.

f) Bourdon element shall be welded to socket and tip end shall be stress relieved.

g) Pressure gauges with range as 0 to 100kg/cm2g and above shall have safety type solid front case. Unless specified otherwise, the pressure gauges shall have an over-range protection of at least 130% of maximum working pressure, as a minimum.

h) Process connection shall normally be 1/2" NPTM bottom.

i) Sensing element for Draft gauges shall be suitable to measure the draft ranges such as capsule, bellows.

j) All pressure instruments shall be provided with 2- valve manifolds along with prefabricated hook ups made of SS316.

k) All Differential pressure gauges shall be provided with 3-way manifold of SS316. It shall be suitable for mounting on 2” pipe. Mounting accessories shall be provided with gauge.

l) All differential pressure gauges shall be of magnetic piston type. Alternatively DP transmitter with local indication shall be provided.

m) All gauges shall be provided with a blowout device i.e. blow out disc of aperture not less than 25mm for gauges with dial size 100mm and above, while 20mm for gauges with dialsize less than 100mm.

n) Diaphragm seal pressure gauge with capillary shall be used for congealing and high viscous services or corrosive fluid, i.e. where plugging of the element may occur or where suitable material is not available in highly corrosive service and where an element protection is necessary or where plugging of element may occur. Size of the capillary shall be selected to ensure response time of the gauge better than 5 seconds. For diaphragm seal pressure gauges with flanged ends, the diaphragm shall be rated for the maximum allowable pressure of the associated flange and spacer ring, isolation valve and plugs shall be provided.

The process connection shall be 1½" flanged for all application except where line size is below 1", chemical seal type pressure gauges with ½"NPT connection are acceptable for 1" below line size.

o) Receiver pressure gauges for local transmitter output indication shall have 100 mm dial with stainless steel element and 1/4" NPTM instrument connection.

p) The dial cover shall be made out of shatter proof glass sheet of thickness 1.5 to 3mm for gauges with dial size less than 100mm while minimum 3.0mm for gauges with dial size100mm or greater.

q) The gauge socket shall be in one piece without any capillary or tube in between forbourdon tube type element and for others tubing with minimum bore of 3millimetres is acceptable. Socket shall be welded type only.

(1.8.2.)Level Transmitter

a) Generally Guided Wave Radar type instruments shall be used for level measurement up to 1219 mm.

b) Differential pressure transmitter shall be used for level measurement above 1219 mm and for services requiring purge or where liquid might boil in external portion.

c) Internal displacer type of level transmitters shall be avoided unless application necessitates its use. Displacer type of level instruments shall be used for interface applications up to 1219mm, and where guided wave radar type level instruments are not suitable. All displacer type of level transmitters shall be of torque tube type with torque tube material of in conel, as a minimum.

d) Non-contact type level transmitters may be used on corrosive, congealing, slurry or services with varying density where diaphragm seal type transmitter cannot be used.

Only ultrasonic or radar type level instruments shall be used for all acid and alkali tanks. Radar Gauges used on tanks shall have inventory capabilities.

e) Differential pressure transmitter shall be used for level measurement above 1500mm, for services requiring purge or where liquid might boil in external portion.

f) Differential Pressure transmitters for use on corrosive or fouling service shall generally be diaphragm wafer with extended filled capillary type. Flush or extended diaphragm type differential pressure transmitter shall be considered for special applications only. Diaphragm material shall normally be stainless steel or any other special alloy.

g) Magnetic Level instruments shall have Float failure indication and their accuracy and scale resolution shall be better than ± 10 mm.

(1.8.3.)Guided Wave Radar & Ultrasonic Level Instruments

a) Guided Wave Radar type Level Instrument shall be based on Time Domain Reflectometry (TDR) principle with type of wave guide i.e. coaxial/ twin rod/ single rod selected by the Vendor. External type instrument shall have external chamber/cage with 2"flanged end connections with ¾" flanged vent and drain connection provided with blind flange. Accuracy inclusive of linearity, repeatability and hysteresis) shall be better than ±3mm, repeatability shall be better than ±3.0 mm, Response time (i.e. 63.2% response) shall be better than 1 second.

b) Ultrasonic type level instrument shall have ultrasonic probe which shall be selected to ensure that distance between the probe and the maximum level of interest is more than the blocking distance of the probe.

Accuracy inclusive of linearity, repeatability and hysteresis shall be better that ±0.25% of measuring range.

c) Radio-frequency type level instruments shall have rod or rope type probe. Accuracy inclusive of repeatability, linearity and hysteresis shall be ± 0.5% of the level measurement range. Generally all the above level instruments shall meet the following;

d) Sensor/ Probe shall be of flanged construction with 2" size. In case of welded flanged connection design, the weld joint shall be of radiography quality. Probe shall be of rugged construction without any mechanical moving part and shall not be affected by abrasion because of fluid turbulence. The probe design shall ensure that the deposits, dust, noise, foam or turbulence in the fluid, shall not affect the performance of the offered level instruments.

e) Instrument electronics shall be shall be of microprocessor based capable of being configured locally, either using an integral keypad or through a hand held configurator and compatible with the associated level probe. It shall comprise of pre-amplifier, converter, transmitter, switching amplifier etc. as applicable for the specified application. Vendor shall ensure that the input/output signals and performance characteristics of individual item provided as a part of each special level instrument are compatible with each other. Instrument electronics shall be integral with the probe.

f) Offered probe/ sensor shall also have compatible certification. Switching Amplifier unit shall have repeatability better than 1%.

(1.9.)Flow Instruments

General: - Flow meter shall be of in-line mounting design with flow direction clearly marked on the flow meter body to ensure correct installation.

Flow meter design shall ensure that the location and / or orientation of installation of flow meter in the line shall not affect the calibration, accuracy and performance of the meter.

(1.9.1.)Variable Area Flow Meter/Rotameter

Variable area flow meters shall be as per ISA-RP 16.1, 16.2,16.3,16.4,16.5 and 16.6 andshall be used for viscous or corrosive services or where range ability in flow precludes the use of an orifice. In general, variable area flow meters shall be selected such that the meter end connections are same as the line size. Flow meter design shall be such that it eliminates the stagnant areas. Flow meter shall have float stops at the top and bottom, which shall be easily removable.

Differential Pressure Valve: Differential pressure regulator shall be used to maintain constant flow rate irrespective of variation in the inlet / outlet operative pressure as per the application indicated.

Vendor shall select a proper differential pressure regulator depending upon the line pressure and the flow requirement. The material of differential pressure valve/constant differential valve and needle valve including the interconnection piping shall be same as flow meter tube material, as a minimum. Performance Requirements: Unless otherwise specified, the variable area flow meter shall meet the following performance specifications;

Flow meter Transmitter Accuracy: better than ± 2% of full scale

Repeatability: better than ± 0.5% of full scale

(1.9.2.)Magnetic Type Flow Meters:

Magnetic flow meter shall be used for electrically conductive slurry or corrosive services with minimum conductivity of 5 mho/ cm and shall be installed with line size bypass, with block and clean out valves, at the lowest point in piping to ensure that meter run is always liquid filled. Flow meter shall be of in-line mounting design insertion type of magnetic flow meter shall not be offered.

Following velocity limits shall be considered for meter sizing.

a) For slurries and viscous flow: 4 to 5 m/s.

b) For all other services: 2 to 3 m/s.

Velocity beyond these limits shall not be considered for sizing.

Flow meter shall be provided with integral earthing reference electrode when installed in onlined pipe and an earthing plate / ring when installed in lined pipe to achieve potential equalization between sensor and liquid. Unless specifically indicated, earthing electrode shall not be acceptable in place of earthing ring. The electrodes including earthing ring shall be connected in the intrinsically safe circuit for flow meter handling electrically hazardous fluids. Magnetic field coils shall operate on an alternating supply voltage, as specified. Coil insulation should be class F suitable for high temperature as per IEC60085/IS 1271. Electrodes shall have good corrosion resistance and shall be welded to meter body. Field replaceable electrode construction shall be offered only when process fluid is coating character. Accuracy inclusive of linearity, repeatability

and hysteresis shall be better than ±0.5% of flow rate and repeatability of the magnetic flow meter shall be better than ± 0.1% of flow rate.

(2.0). ANALYSERS

General

Vendor shall be responsible to supply all ClO_2analysers required for the System.

Vendor to note:

a) Vendor "s scope shall include supply of ClO_2analyseras per requirement of finally approved P&IDs & other process documents and as per specifications complete with sample system designed for the specific purpose.

Vendor shall supply in-line analysers with necessary transmitters mounted in the field. Analysers shall be capable of withstanding line pressure and temperature conditions.

Analysers shall be supplied as per the approved P&IDs with functional requirements as specified elsewhere. Where no specifications are available, Vendor shall detail out the same in line with international codes and practices, specifications provided with this document and last but not the least as per good engineering practices followed by analyser industry. In all such cases, Vendor in their own interest must get performance specification reviewed by Owner/Owner Representative before proceeding with further engineering &procurement.

b) All analysers shall be micro-processor based in general and shall be capable of providing detail diagnostic alarms, messages to help maintenance personnel. These system alarms shall be connected to the PLC system in Central Control Room. The configurational data of the analyser including set range shall be stored in a non-volatile memory. Vendor shall provide smart transmitters, in general, for all the analysers.

However in case SMART transmitters are not available for any particular type from the approved vendors, Vendor may supply Non-Smart type.

c) The span of the analyser shall be adjustable from the analyser front without opening the analyser enclosure. In case separate device is required to make such a change, same shall be included.

d) The material of construction selected by Vendor must be in suitable for fluid being handled. Vendor must select SS316 as a minimum.

e) All components of the analysers shall be certified suitable for the hazardous area classification.

f) The design of sample system for all the above analysers shall ensure a clean representative and measurable sample for the selected analysers. System shall include sample probe, pressure reducing station, filters, regulators, relief valves, sample cooler etc. as required. The design shall include a sample flow switch, which will provide alarm and inhibit analysis whenever a low flow is sensed. Filters shall always be provided in dual configuration. It shall be possible to replace the filter without upsetting the operation of the analyser. Vendor shall consider provision of fast loops and sample return to process as

necessary to meet performance requirements. The sample return shall not be vented or routed to drain unless the return is a waste product.

g) The configurational data of the analyser including set range shall be stored in a nonvolatile memory such that this remains unchanged because of power fluctuations or power off condition.

In case vendor standard instrument has battery backed RAM, vendor to ensure that battery drain alarm is provided as diagnostic maintenance message.

h) Vendor shall be fully responsible for and shall arrange for analyser sub-vendor assistance for commissioning of the analyser system.

i) All the analysers shall be supplied pre-assembled, pre-tubed and pre-wired condition complete with sample handling system. All the interconnecting wiring shall be colour coded/numbered and terminal blocks shall be clearly identified.

(2.1.)<u>Density Indicator Transmitter</u>

a) General Information

1. Type	Density Indicator
2. Service	To check density of 32% HCl acid in storage tank

b) Instrument Characteristics

3. Sensor Type	process compatible
4. Accuracy	<3%
5. Drift over time	<5%/year
6. Measuring range	700-1400 kg/m3
7. Fluid handled	32% HCl acid in storage tank
8. Operating Pressure	<2bar
9. Response Time	< 120 secs
10. Power Supply	2 wire loop powered 24vDC/4 Wire 110V AC ± 10% 50Hz ± 1%
11. Analog Output	4-20 mA
12. Display	LCD display (4 Digits) with backlight
13. Material of Body	Aluminium LM25
14. Mounting details	local on 2" pipe, mounting kit (bracket, clamp, nuts etc.) to be supplied or flat vertical surface such as wall , panel, stand or on top of tank.etc
15 IP Rating	IP 66

c) Test to be carried out

16. Calibration check	Single Point Calibration
17. Power ON, Simulation Check	Manufacturer Test Certificate

d) Testing Standard

18. Design Standard	Manufacturer Standard
19. Testing Standard	Manufacturer Standard

(2.2.)PAINTING AND PROTECTION

Painting and protection of chemical plant and pipe-work shall be as specified for mechanical plant in the Mechanical Plant part of the Specification.

(2.3.)CHLORINE DI-OXIDE

Scope

This Section contains requirements which, where relevant to this Contract, shall apply to the supply, installation and testing of chlorine di-oxide plant.

General

Chlorine di-oxide plant shall be designed to the guidelines in 'Safety Advice for Chlorine di-oxide Installations'; HS/G 28,1999 and 'Safe Handling of Chlorine di-oxide ; HS/G 40, 1999, Health and Safety Executive, UK, as applicable.

All valves shall be Euro Chlor (Avenue Louise 250, Box 72, 1050Brussels, Belgium) or US Chlorine Institute approved or equal.

(2.4.) SOLUTION ISOLATING VALVES

Manual isolating valves for chlorine di-oxide solutions shall be of the ball type with CPVC bodies.

End fittings may be plain sockets for solvent welding or flanged as appropriate.

(2.5.)INJECTION FITTINGS

Where chlorine di-oxide to be dosed into flow in an open channel, weir chamber, contact tank or downstream of a hydraulic pump, it shall be applied using a submerged chlorine di-oxide solution distributor.

The distributor shall be 55.316 L internally hard tubular rubber lines diffuser, designed to ensure uniform distribution of solution at the point of application.

Where chlorine di-oxide solution is to be dosed into flow in pipelines, it shall be applied using an injection fitting/device designed for the specified duty flow rate.

(a) Pipelines up to 600mm in diameter.

The injection tube shall extend one-third of the pipeline diameter into the fluid stream. In this case a with drawable type injection fitting entering the pipe through isolating valve internally PTEF lined be used.

(b) Pipelines up to 1000mm in diameter.

The injection tube shall be external/internal PTEF lines shall extend right across the pipe bore and be supported with ends located in diametrically opposite flanged branches.

The tube shall be drilled at predetermined centres to ensure uniform distribution across the flow profile.

(c) Pipelines up to 2500mm in diameter.

Two perforated injection tubes shall be used, each generally as for (b) only installed mutually at right angles and with their axes at 45^{o} to the horizontal in a plane normal to the direction of flow within the pipeline.

Alternatively, four injection nozzles, mutually located at 90^{o} and extending 15% of the pipe diameter shall be installed. The nozzles shall be installed in diametrically opposite flanged branches and in the same plane normal to the direction of flow in the pipeline.

The nozzle velocity shall exceed 0.75m/s or one half the large pipe velocity whichever is greater.

Distributors and injection fittings shall be of sturdy design and adequately supported and designed to withstand the flow velocity at the point of application and any flow or turbulence induced vibrations.

The materials of construction of the distributors, and sealing shall be compatible with up to 3500 mg/l chlorine di-oxide solutions at operational fluid temperatures up to $25^{o}C$. Porous ceramic material where used shall be inert and non-toxic. CPVC tube where used shall conform to BS 3506, Class E.

Chlorine di-oxide solution distributors or injection fittings shall be supplied complete with the necessary non-return and isolating valves (CPVC).

(2.6.)WIND MONITORS

Wind direction shall be monitored by a wind vane of the counter balance tail type capable of responding to winds greater than 0.25 m/s and shall have a range 0 to 360^{0} with an accuracy of ±2%.

Wind speed shall be monitored by a 3-cup anemometer with a range of 0.25 to 45 m/s and an accuracy of ±1%.

The wind vane shall be constructed of aluminium and the counter balance and the shaft shall be constructed of stainless steel. The cup assembly shall be of polycarbonate construction with the shaft in stainless. The sensor bodies of the instruments shall be designed to prevent signal disruption due to rain, condensation, temperature changes or vibration. The instruments shall have an operating temperature range of - 10^{0} to 55^{0} C and shall be able to withstand wind speeds up to 50 m/s.

In applications where both the instruments are provided they shall be mounted on a single cross or vertical arm of stainless construction and the complete assembly shall be mounted at a suitable height above ground away from buildings. A suitable means of access to the instruments for maintenance shall be provided. Each instrument shall be provided with a transmitter and the output 4-20ma signal derived shall be used to indicate the information on remote panels as specified.

Wind sock shall be of the cloth cone type opened at both ends and used to indicate wind direction. It shall be made of orange coloured nylon cloth with hems and seams double stitched and sock laced on to a ring frame that shall support the throat. The frame shall include a 1 m pipe of stainless steel construction suitable for attachment to a supporting pole. The sock shall be at least 2.5 m long with a throat diameter of not less than 0.5 m.

(2.7.)ISOLATING VALVES

(a) General

All isolating valves shall be positioned with due regard to routine access for operational and maintenance purposes. It shall not be necessary to enter any bunded facility to operate isolating valves.

Isolating valves shall be compatible generally with the pipe-work systems in which they are installed.

(b) CPVC Valves

Isolating valves shall be of the ball type with CPVC bodies, glass filled polypropylene top works and PTFE diaphragms. Assembly nuts and bolts shall be stainless steel.

End fittings may be plain sockets for solvent welding or flanged as appropriate. Flanges shall be to BS 4504 PN16 minimum.

These valves may not be used for isolating tank outlets and drains unless otherwise approved by the Engineer.

(c) Rubber Lined Valves

General isolating valves shall be of the diaphragm type to BS 5156 with weir bodies in grey cast iron to BS 1452 grade 220 (or alternative grade allowed by the design standard) having integral flanged ends, a natural rubber ebonite lining, PTFE diaphragms and top works in standard proprietary materials. Assembly nuts and bolts shall be in stainless steel. The valves shall be flanged to BS 4504 PN10 minimum.

Main isolating valves for tank outlet and drain shall be of the tapered plug type with PTFE sleeve and cast iron body.

All valves shall be tested in accordance with BS 6755: Part 1.

(2.8.)WATER SAMPLING EQUIPMENT

(2.9.)GENERAL REQUIREMENTS FOR SAMPLING

(2.9.a.)Sample Points

Sample points shall be provided as specified for example to provide a means of efficiency monitoring and controlling the works and to allow comparison of performance of different process units and otherwise where recommended by the Contractor to suit his design.

(2.9.b.)Location

Sample points shall be positioned in a manner which ensures that the sample is properly representative of the fluid stream from which it is taken in terms of physical, chemical and microbiological parameters.

Special care shall be taken following chemical dosing to ensure that mixing has taken place before the sample is withdrawn.

In pipelines up to 600 mm in diameter, the limiting position of the sample point shall be where the ratios of minimum concentration to maximum concentration of the dosed chemical across the horizontal and vertical diameters of the pipeline are at least 0.95.

In pipelines larger than 600 mm in diameter, these ratios of concentrations shall not be less than 0.90 or, where applicable, such higher value as may be necessary to achieve the stated plant performance guarantee. Similar criteria shall apply to flow in channels and rectangular ducts of all sizes except that the concentrations shall be across the horizontal and vertical centre axes.

(2.9.c.)Off take Arrangement

In no circumstances shall samples be withdrawn directly from the pipe or channel wall. Sample withdrawal tubes shall project into the bulk fluid flow in a manner which avoids vibration and the collection of entrained gas bubbles or sediment.

Sample tapping points shall not be less than 1" NB. Generally, any reduction in pipe size shall take place after the first isolating valve.

The off take arrangement up to and including the first isolating valve shall be designed for maximum mechanical strength in addition to hydraulic considerations and the integrity of the main fluid stream shall not be prejudiced by any failure in or damage to the sampling system itself.

Samples from pipes for closed loop control shall be withdrawn from the central 1/3 td of the pipe. The sample pipe shall have substantial support shaft to prevent velocity induced stress and vortex shedding and a profile head to minimise hydraulic interference effects.

Samples drawn from pipes downstream of mixers shall be provided with a flanged seal housing to permit insertion and withdrawal of the sample probe under pressurised pipeline condition.

(2.9.d.)Sampling Rate

The sampling rate shall be optimised for each sampling system with due regard to the following:-

- The purpose of sampling;
- Maintenance of sample quality;
- Effective monitoring and control, where applicable;
- Hydraulic restraints;
- Minimisation of wastage.

The sample delivery rate to analysers shall be as recommended by the instrument manufacturers and any necessary pressure or flow regulating device to maintain this shall be provided.

The sample delivery rate to sample taps shall be limited to 2 litres per minute per tap by means of suitable preset or flow limiting valves but not by use of isolating valves.

Generally, samples shall be delivered at rates significantly in excess of those required by analysers and sample taps to satisfy all relevant design criteria. Typically sample flow rate shall be about 50 times the sample flow to each analyser. Sample pipe-work shall not be less than 0.5" (12 mm) nominal bore under any circumstances and, where hydraulic or water quality conditions dictate shall be larger.

(2.9.e.)Sample Recovery and Disposal

Unless otherwise specified, excess sample water shall be recovered for re-use provided that there is no risk of contamination and that it can be returned to the process at a suitable point and always prior to final disinfection.

In this way, wastage shall generally be limited to discharge of used samples from analysers and from sample taps.

All necessary means shall be provided for collection and disposal of waste sample water with due regard to any contaminants which may be introduced within the sampling facility such as analytical reagents or cleaning compounds.

(2.9.f.)Sample Validation

All sample systems shall be provided with pressure gauges and the gauge diameter shall be 100 mm. The gauges shall be mounted at the receiving end of the sample system such as above the sample sink.

Where samples are delivered to water quality analysers, that part of the flow received by each analyser shall be validated by means of a flow switch or, where hydraulic conditions permit, a pressure switch. In either case, volt-free contacts shall be provided for initiation of an alarm condition and, where applicable, instrument and/or reagent shut-down.

Sample systems shall be adequately protected from frost where necessary by trace heating and lagging.

(2.9.g.)Sample Pumps

Unless otherwise specified or approved, sample pumps shall be of the progressive cavity type with flange mounted three phase cage induction electric motors.

The pumps shall have close grained cast iron bodies, stainless steel rotors, synthetic nitrile rubber stators and mechanical shaft seals. (Impeller and shaft should be S.S – 316)

Sample pumps shall be installed above flood level wherever possible and shall be readily accessible for maintenance purposes.

Over-pressure protection shall be provided either by means of an integral device or a separate pressure relief valve.

Where specified, sample pumps shall be installed in duplicate and arranged for automatic changeover on failure. Otherwise, spare sample pumps shall be supplied boxed at a rate of at least one per four pumps installed to be substituted as and when required. Single pumps shall be powered by way of a local plug and socket arrangement to facilitate easy substitution.

(3.0.)SAMPLE PIPEWORK

(3.0.a)General

Sample pipe-work shall be selected to suit the application and type of measurement from CPVC, stainless steel or duct-iron. In addition, medium density polyethylene pipe may be used where appropriate only for sections run through buried ducts or laid directly in the ground.

(3.0.b)CPVC Pipe-work

CPVC sample water pipe-work shall be the `hi-impact' type to BS 3505 Class E with solvent welded joints and fittings complying with the relevant parts of BS 4346.

Screwed connections to metal components such as sample pumps shall be made with proprietary iron to CPVC adapter fittings.

Pipe-work shall be supported in accordance with manufacturers' recommendations and adequate provision shall be made for thermal expansion and contraction.

CPVC pipe-work shall not be used where it may influence analytical measurements such as dissolved oxygen concentration.

(3.0.c)Stainless Steel Pipe-work

Stainless steel sample water pipe-work shall be type 316S11 or higher grade to BS 3605 Part 1 with tolerances in outside diameter to Table 1 of BS 4368 Part 3 and tested in accordance with Category 2 requirements.

Pipe couplings shall be light series compression Type A to BS 4368 Part 3.

Pipe-work shall be supported directly on surfaces with proprietary clips or, where several lines follow a parallel route, they may be clipped to trays dedicated to this service.

(3.0.d)Ductile Iron Pipework

Ductile Iron sample water pipe-work may be used for those sections which are run through buried ducts or laid directly in the ground.

(3.1.)SAMPLE ISOLATING VALVES

(3.1.a.)General

The valves shall be compatible with the main sample pipe-work system, CPVC or stainless steel.

(3.1.b.)CPVC Valves

Isolating valves shall be of the diaphragm type with CPVC bodies, glass filled polypropylene top works and PTFE diaphragms. Assembly nuts and bolts shall be stainless steel.

(3.1.c.)Stainless Steel Valves

Isolating valves shall be of the diaphragm type to BS 5156 with weir bodies in stainless steel 316C16 to BS 3100, PTFE diaphragms and top works in standard proprietary materials. Assembly nuts and bolts shall be stainless steel. The valves shall be tested in accordance with BS 5146 Part 2.

(3.2.)SAMPLE TAPS

Sample taps shall be in chrome plated brass, □" BSP size, with cross handle and outlet nozzle suitable for sterilisation by flaming. The nozzles shall have protective screw on caps which are attached by means of chain to the tap spindle.

(3.3.)SAMPLE SINKS

Sample sinks shall be to BS 1206, nominally 455 mm wide by 255 mm deep and length to suit the number of sample taps:

- up to 4 samples610 mm
- 5 samples760 mm
- 6 samples915 mm

The sinks shall generally be supported from a wall on cantilever brackets but where this is impracticable, they may be supported on stanchions from the floor. The base of the sink shall be approximately 700 mm from the floor and shall be fitted with a drain connected to an approved discharge point.

The sample tap nozzles shall be positioned at 100 mm centres at a distance of 170 mm from the rear of the sink and at a suitable height above the sink to allow collection of samples in a glass bottle approximately 300 mm high.

(3.4.)WATER SAMPLING EQUIPMENT

(3.4.1.)Off-site Inspection and Testing

Tests shall be carried out on all items of plant to demonstrate compliance with relevant standards. Pumps shall be tested as specified.

Unless otherwise specified or instructed by the Engineer, the tests shall be in accordance with the Reference Standards, the manufacturers' own tests where applicable.

(3.4.2.)Individual Tests

(a) The following inspections and tests shall be carried as appropriate :

(b) Inspection to check the assembly of the Plant and conformity with the Specification and approved Drawings.

(c) Sample water pipe-work and components shall be tested hydrostatically for 1 hour at 1.5 x maximum working pressure or 5 bar g whichever is greater. During the test the pressure shall not change.

(d) Drain pipe-work shall be flushed and inspected visually for absence of leaks.

(e) Water quality monitoring instruments shall be tested as specified.

(3.4.3.)Preliminary Tests

Testing shall incorporate the following requirements:

(a) Functional testing of the sampling system (including water quality monitoring instruments).

(b) Sample lines including those to the clarity bowls and fish tanks shall be flushed and delivery rates checked for example by timing water into a calibrated vessel against a stop watch.

(3.5.)SAFETY EQUIPMENT

(3.5.1).Safety Showers

Safety showers shall be purpose-designed proprietary units suitable for indoor or outdoor use as specified.

The showers shall incorporate nozzles specially designed to create a deluge of water overhead for rapid decontamination and an additional spray at approximately waist height to direct water onto the lower body and legs. The water supply valves shall be mechanically operated by means of a grab handle. Where specified, the units shall be fitted with limit switches with volt-free changeover contacts for initiation of a remote alarm when the shower is operated.

The showers shall be connected to a secure water supply to ensure highest possible availability. A pressure gauge shall be provided for the supply to each unit. The shower collecting tray shall be connected to an approved discharge point.

The appropriate safe condition signs shall be fixed in conspicuous places.

(3.5.2.)Eye Baths

Eye baths shall be either self-contained units or integrated with safety showers as appropriate. They shall be of a purpose-designed proprietary type suitable for indoor or outdoor use as specified.

They shall incorporate fine mesh filters and pressure regulators to ensure a safe flow of water for eye irritation. The water supply valve shall be mechanically operated by means of a tread bar. Frost protection shall be provided.

The eye baths shall be connected to a secure water supply to ensure highest possible availability. A pressure gauge shall be provided for the supply to each unit. The collecting basin drain shall be connected to an approved discharge point.

The appropriate safe condition signs shall be fixed in conspicuous places.

(3.6.)PROTECTIVE CLOTHING

(3.6.1.)General Requirements

Protective clothing shall be supplied in sets in the quantities specified and shall comprise those articles appropriate to routine operations and maintenance work in the designated areas of the Works.

Where articles are manufactured in various sizes and are not readily adjustable, then each set shall include a range of at least two fittings covering medium and large sizes unless otherwise specified.

(3.6.2.)Helmets

Helmets shall be of the general purpose industrial safety type complying with BS 5240 and incorporating an adjustable harness. The colour of the helmets shall be yellow unless otherwise specified.

(3.6.3.)Overalls (Chemical Resistant)

Overalls for chemical handling shall be of the boiler suit pattern manufactured from plasticised PVC or PVC proofed nylon with welded seams and integral hood. Front

fastening shall be by means of a zip with button-over protective flap. The overalls shall be impervious and resistant to acids and alkalis at the maximum concentrations used in the Works.

(3.6.4.)Gauntlets (Chemical Resistant)

Gauntlets for chemical handling shall be of the heavy duty pattern with an overall length of at least 400 mm and manufactured from PVC. The external finish shall be smooth.

3.6.5.Gloves

Gloves for general use including the handling of steel drums and cylinders shall be of heavy duty leather and fabric construction complying with BS EN 388 and BS EN 420.

(3.6.6.)Boots

Safety boots shall be in moulded polyvinyl chloride complying with BS EN 345 and BS 6159 Part 1. The boots shall have protective mid-soles and safety toe-caps.

(3.6.7.)Storage Lockers

Storage lockers for protective clothing shall be of the floor standing single compartment type constructed from 22 swg steel with concealed hinges and key operated locks. Each locker shall have a hat shelf and double coat hook. Lockers shall be located away from hazardous areas but within convenient reach thereof. The lockers shall be suitably labelled as to purpose.

(3.6.8.)Self-Contained Breathing Apparatus

Self-contained breathing apparatus shall provide complete respiratory protection from the surrounding atmosphere for a period of 60 minutes at normal breathing rate. The apparatus shall comply with BS EN 137 and shall be type approved by the Engineer.

Each set of apparatus shall incorporate an air cylinder, pressure reducing valve, pressure gauge, demand valve, panoramic vision face mask, bypass valve and adjustable harness with waist strap. The apparatus shall include a warning whistle to indicate approaching exhaustion of the cylinder.

A spare cylinder shall be supplied with each set.

All air cylinders shall be pre-charged with air meeting the requirements of BS 4275.

Each set of apparatus shall be capable of accepting an additional face mask complete with its own demand valve and supply hose.

Each set shall be accommodated in a purpose-designed wall-mounting cabinet of a non-locking type with lift-off front cover. The cabinet shall be suitably labelled.

(3.6.9.)Cartridge Type Respirators

Cartridge (or canister) type respirators shall comply with BS 7355 and shall be of the full face piece type unless otherwise specified.

Cartridges (or canisters) shall comply with the relevant sections of BS EN 141, BS EN 143, BS EN 371 and BS EN 372.

Each respirator shall be supplied with a pack of at least three spare cartridges or canisters.

Each set shall be accommodated in a purpose-designed wall mounting cabinet of a non-locking type or, where specified, in a suitable hand carrying case. Cabinets or cases shall

be suitably labelled. The labels shall state the intended use and maximum concentration of the contaminant and exposure time for which the cartridge or canister is suitable.

(3.7.0.)Face Masks

Face masks for protection against dust shall comply with BS 6016 and shall be fully disposable.

Masks shall be supplied in packs of at least 20.

(3.7.1.)Eye Protection

Eye protection against gas, liquids and dust shall comply with BS 2092 grade 1.

The protection shall be of the goggle type with polycarbonate front lens and anti-mist acetate rear lens.

(3.7.2.)Ear Protection

Ear protection shall be of the ear muff type complying with BS EN 352-1 Part 1 and tested in accordance with BS 5108 EN 24869-1.

Ear muffs shall be accommodated in purpose-designed wall mounting cabinets of a non-locking type which shall be suitably labelled. Cabinets shall be located immediately outside areas where sound attenuation is required.

(3.8.)PORTABLE GAS DETECTORS

Portable gas detectors shall be suitable for the detection of flammable gas/vapour, toxic gas/vapour and/or oxygen deficiency as appropriate to the Works.

Flammable gas/vapour detectors shall comply with the relevant parts of BS EN 50054, BS EN 50055, BS EN 50056, BS EN 50057 and BS EN 50058.

Detectors which are electrically operated shall be intrinsically safe to BS EN 50014 and BS EN 50020 and shall have the appropriate BASEEFA approval code but not less than Exia IIC T3.

Battery operated detectors which are rechargeable shall be supplied with a charger suitable for mains operation at 240V a.c. unless otherwise specified.

Each detector shall have the following features:-

- Selector switch OFF-TEST-ON.
- Indicator lamp for POWER on.
- Indicator lamp for ALARM condition.
- Audible alarm.
- Pushbutton for alarm RESET.
- Analogue or digital indicator for GAS CONCENTRATION.
- Carrying strap and/or belt clip.

Protective storage case.

Flammable gas detectors shall read % LEL and shall have the calibration gas engraved on a permanently fixed plate. The calibration gas shall be methane unless otherwise specified.

Toxic gas detectors shall read ppm of the specific toxic gas which shall be engraved on a permanently fixed plate.

Oxygen detectors shall read % O_2 up to at least 25% O_2. In situations where oxygen enrichment of the atmosphere may occur, for example by leakage from oxygen handling plant, two adjustable alarm levels shall be provided at nominal values of 18% and 24% respectively.

(3.9.)FIRST AID KITS

First aid kits shall be contained in wall mounting boxes designed to protect the contents from dampness and dust and marked with a white cross on a green background.

Unless otherwise specified, each box shall contain the following items:

- First aid guidance card;
- 20 individually wrapped sterile adhesive dressings of assorted sizes;
- 2 sterile eye pads with attachments;
- 6 individually wrapped triangular bandages;
- 6 safety pins;
- 6 medium sized individually wrapped sterile unmedicated wound dressings (approximately 100 x 80 mm);
- 2 large individually wrapped sterile unmedicated wound dressings (approximately 130 x 90 mm);
- 3 extra-large individually wrapped sterile unmedicated wound dressings (approximately 280 x 175 mm).

Additionally, where eye wash bottle sets are not provided separately in the immediate vicinity,

- 3 No. 300 ml of sterile water or sterile normal saline solution (0.9%) in sealed disposable containers.

Additionally, where soap and water of drinking quality are not available in the immediate vicinity,

- 12 individually wrapped moist cleansing wipes.

(4.0.)FIRE BLANKETS

Fire blankets shall be of the heavy duty industrial type complying with BS 6575 and contained in wall mounting cabinets suitably labelled with white lettering on a red background.

(4.1.)VENTILATORY RESUSCITATORS

Ventilatory resuscitators shall comply with BS 6850 and shall be contained in a carrying case suitably labelled with white lettering on a green background.

(4.2.)SAFETY SIGNS

All labels and signs providing health and safety information or instructions shall comply with BS 5378. Fire safety signs shall comply with BS 5499 Part 1.

Signs which are not integral parts of the safety equipment and which are fixed separately to cabinets or to nearby surfaces shall be manufactured in accordance with Part 4 of this Specification.

(4.3.)LABORATORY SERVICES

(4.3.1.)General

Service pipework shall be located as far as possible behind the sectional units and shall be readily identifiable for purposes of inspection and repair.

(4.3.2.)Plumbing

Pipework for plumbing, except drain fixtures and fittings, shall be a red-brass composition containing at least 85% copper, with washers and seats of maximum wear - resistant materials for the specific use. Above-bench fittings and taps shall have a corrosion-resistant polythene finish.

In main laboratory areas, sinks shall be of glazed epoxy resins, fitted beneath the bench top the bench top being cut to overhang the sink and throated on the underside to provide a water break.

Waste systems shall be supplied in "Vulcathene" or similar high density polythene. All sinks shall be fitted with suitable anti-siphon bottle traps, with removable bases.

(4.3.3.)Electrical Fittings

Extraction fan motors shall be wound for single phase or three phase 50Hz AC, supplies. Within the laboratory area, all conduits and distribution boards shall be able to provide a minimum of 10% additional capacity. No socket outlet shall be placed on a bench or in a fume-cupboard in such a position that a spill of liquid can constitute a hazard.

(4.3.4.)Office Furniture

A suitable number of desks chairs, laboratory stools and adjustable height laboratory chairs shall be provided.

4F.02. WATER TREATMENT CONTROL PHILOSOPHY

CONTENT

(1.0) CONTROL OF CHLORINE DI-OXIDE PLANT

(1.1.) GENERAL

A. The plant control shall be by dual redundant PCU (processors, power supply, I/O modules, communication modules, and F.O communications, etc..) for fully automatic control of the chlorine di-oxide generating & dosing plant . Control and monitoring of the plant shall be provided at the chlorine di-oxide plant Local Control Panel that shall be located in the field. All signals (monitor/control) shall be duplicated at LCP and shall be connected through DAC system in the main Control room located in the Mutla High Site-2 chlorine di-oxide building.

B. The complete operation and control of existing chlorination plant site-1 facilities should be transferred to new chlorine di-oxide building site#2. Both the existing site-1 and new site-2chlorine di-oxide plant should be operated and controlled from new site-2 building (Control room) with same terms of operation & control)

(1.2.) CONTROL FUNCTIONS

At the chlorine di-oxide plant locally mounted panels shall be provided to control the following functions.

- Raw chemical Sodium chlorite - in use , - solniod valve Open/close ;
- Raw chemical Hydrochloric acid tank - in use , - solniod valve Open/close
- Sodium chlorite &Hydrochloric acid unloading pumps.
- Storage tanks level status.
- Motive water pump.
- Chlorine di-oxide generator.
- Dosing pump.
- Sampling pumps.
- Air conditioning & Ventilation (in the switch room).

Information and alarms from each of these locally mounted panels shall be repeated at the respective chlorine di-oxide Plant Local Control Panel and the respective workstation in the Main Control Rooms.

The complete plant including the control system shall be designed to ‘fail safe’.

Interlocks shall be provided to ensure that the equipment is protected from damage against abnormal operations.

This section shall read in conjunction with all other division of specs and drawings.

(1.3.) CHLORINE DI-OXIDE DOSING PLANT

The controls to be provided for chlorine di-oxide dosing plant shall include:

- AUTO and MANUAL selection for the chlorine di-oxide generator skid.
- AUTO and MANUAL selection for the each dosing point (i.e. generator and

Associated ejectors);

- Raw- chemical tank levels& motorized valves.
- Chlorine di-oxide Generator duty selection to enable the selection of generator in order to be DUTY and STANDBY.

  ClO_2 generator skid and associated ejector each for point of application.
- Duty/Standby selection for motive water pumps based on the low pressure/flow

Two ClO_2 generator skid shall be arranged to operate as duty/standby each supplying the total chlorine di-oxide demand. On failure of the duty unit, the second standby unit shall supply the total chlorine di-oxide demand of the treatment works. Changeover of the generator skid and motive water pumps from duty to standby on failure of the duty shall be automatic.

The chlorine di-oxide dosing rate shall be proportional to the flow rate measured in the pipe into which chlorine di oxide is being dosed. In combination flow proportioning the chlorine di-oxide dose shall be controlled in proportion to the difference between the desired chlorine di-oxide and the measured chlorine di-oxide (measured after the chlorine di-oxide has mixed in the water.) within a pre-set dead band.

It shall be possible to set the dose signal from HM1; flow proportioning shall remain effective.

In the event of a failure of the flow signal or chlorine di-oxide signal, the dosing pump shall operate at the valve fixed prior to the failure and the corresponding failure shall annunciate an alarm at the local control panel and DAC system.

1- Air conditioning system running continuous and link with ventilation system, ventilation system will be active on chlorine di- oxide leak alarm/ signal on ClO_2 leak signal air conditioning system stop automatically and ventilation system will start as per leak signal it should be indicated on LCP &DAC.

(1.4.) AIR CONDITIONING AND VENTILATION

Air conditioning and ventilation plant serving the chlorine di-oxide generator room shall be operated as one system, separate from pump room Air conditioning and ventilation.

The selection of duty/standby fans shall be made on the ventilation plant control panel.

The control to be provided for chlorine di-oxide plant ventilation on the ventilation control panel shall include.

(1.5.) CHLORINE DI-OXIDE PLANT CONTROL PANEL

The chlorine di-oxide plant control panel in the chlorine di-oxide generator building shall be provided with all necessary control switches, state indications and alarms as applicable for routine.

Monitoring, commissioning, manual operation, abnormal operation, testing and maintenance of the plant.

Additional information to be provided on the local control panel shall include.

- Sodium chlorite solution tank in use;
- Hydrochloric acid solution in use;
- AUTO and MANUAL states for chlorine di-oxide generator & dosing and the ventilation/ AC plant;
- DUTY and STANDBY states for chlorine di-oxide generator & dosing skids;
- Chlorine leak low and high in each area;
- Low level of $NaClO_2$& HCl storage tanks chlorine -dioxide generating & dosing system will stop automatically;
- Chlorine di-oxide generator motive water supply flow low; generators system stop automatically.
- ClO_2 output control signals fault;
- Ventilation system running/stopped;
- Safety shower operated;
- Ventilation system fault;
- Motorized valves open/close position;
- Motorized valve fault.
- Flow Rota meter flow ratesof$NaClO_2$, HCl and motive water supply.

Local alarm panels of the "traffic" type with green for all clear, amber for low level leak and flashing red for high level leak shall be provided and located as follows:

- Entrances to the chlorine di-oxide generating, pump rooms.
- Chlorine di-oxide injection chamber.

The flashing red lamps shall be repeated above the entrance doors with illuminated "DANGER CHLORINE DI-OXIDE LEAK" warning signals.

The diameter of each alarm light shall be not less than 100mm. additionally a high level leak shall sound an external siren type audible alarm (of tone different to that of the fire alarm). A push button shall be provided on the ventilation control panel in the switch gear room for muting the siren audible alarm. As the leak level falls, the flashing red light shall revert to the amber light but the amber light shall remain even after the leak has been cleared, until its reset from the hardwired switch located on the mimic in the plant control room. A flashing red light shall illuminate if any extractor fan is failed, isolated, stopped by emergency push button.

Interlocks shall be provided to ensure that the equipment is protected from damage against abnormal operations. These shall include measures to prevent starting of pump until motorized valve are open, and running of mixer until the propeller is submerged. All pumps shall be arranged to trip on low low level in corresponding suction tanks.

(1.6.)VIDEO MIMIC ALARM ANNUNCIATOR.

The video mimic alarm annunciators window signal shall include from the chlorine di-oxide systems. Such as pump fault, chlorine di-oxide high/low, pressure high/low, flow high/low, duty equipment failed, communication fault, chlorine di-

oxideleak, vacuum high/low, UPS fault, Main power fail, etc. and remote sites SR/NR chemical plant critical alarms.

(1.7.) GuaranteedMaintenance

Whole control system should be maintained & guaranteed for period of 2 year. Spares are included for maintenance equipments.

Spares for two year operation period for all control equipments as recommended by Manufacture (Break down to be submitted)

4F.02 TECHNICAL SPECIFICATION FOR CHLORINE DIOXIDE GENERATING SYSTEM

CONTENTS

ABBREVIATIONS

- Reverse Osmosis (Potable Water) ---------- R.O (Potable Water)
- Fresh Water ---------- F.W
- Chlorine Dioxide ---------- ClO_2
- Sodium Chlorite ---------- $NaClO_2$
- Hydrochloric Acid ---------- HCl
- Instrument & Control ---------- I&C
- Water Distribution Complex ---------- WDC
- Total Dissolved Salt ---------- T.D.S
- Total Suspended Salt ---------- T.S.S
- Temperature ---------- Temp.
- Distillation Plant ---------- Dist. Plant
- Local Control Panel ---------- LCP
- Process Logic Control ---------- PLC
- Heating, Ventilation & Air-conditioning ------ HVAC
- Intermediate bulk container ---------- IBC
- Material of Construction ---------- MOC
- Rein-forcement-concret ---------- R.C
- Chlorinated Polyvinyl chloride ---------- CPVC
- Unplasticized Polyvinyl chloride ---------- UPVC
- Polyvinyl chloride ---------- PVC
- Litre per second ---------- L/s
- Kilogram per hour ---------- kg/hr
- Human Machine Interface ---------- HMI
- Million Imperial Gallon per day ---------- MIGD `

Water Disinfection by Chlorine Dioxide Plant
Technical Specification

On site Production of Chlorine-Dioxide" Under Water & Under-Vacuum Type" Generating System used for Disinfections of Potable Water

(1.0.) General (Scope of Work):

(a) The intent of this specification is to design, Supply, Install, Test, Commissioning and handover the complete ClO_2 (Chlorine dioxide) producing bromate free potable water disinfection system for water flow rates of inlet/outlet lines of Multa High reservoirs sites (Nos. 1, 2 & 3) as mentioned in specification & tender drawings, including chemical storage tanks, loading pump, dosing pumps, water storage tank, option ≠ 1 Submerged Under Water Type & option ≠ 2 Under Vaccum Type chlorine dioxide generators, dosing pumps, operation and electrical panels. The system should be complete in all respect including pipe-works, valves & fitting with ClO_2 injection lances up to point of application. Including supply of chemicals for two years (enough for 24 months treatment according to Maximum ClO_2 dosing rate (0.8 mg/l) for Water flow rates/water production as mentioned below:

Groups:	**Water Production**
Group A: • R.O (Potable water) from Doha Distillation plant via 4 NOs of 1200mm DIA incominglines to Mutla High Reservoir	120 MIGD
Group B: • Blended (F.W) from Subiya WDC via 3 Nos. of 1200mm DIA lines incoming to Mutla High Reservoir	100 MIGD
Group C: • Fresh Water from Mutla High WDC going to West-Funaitees-II via 3 Nos. 1200mm DIA (C4/Lines).	100 MIGD
Group D: • 1200mm DIA Line from Mutla High out-going to Jahra • Fresh Water from Doha to Mutla High via 1200mm DIA line • Fresh Water from Mutla High WDC to Mutla Low and Abdaly	 30 MIGD 30 MIGD 15 MIGD

- 24 months (2 years) full guarantee for operation & Maintenance of onsite ClO_2 generating system used for disinfection of potable water by contractor (including spares needed).
- Bromate, chlorite and chlorate Concentrations to be under the World Health Organization (WHO) guidelines.

The system should be complete with ventilation equipment, air conditioning system, fire detection system as mentioned in tender specification & safety equipment's / other accessories specified and required to provide a comprehensive (ClO_2 generating on site) plant in all respect, including selection & sizing of equipment's, storage tanks, piping, hydraulic calculation, system layout & PIDS drawings, Isometric, cross section etc. as per MEW standard design & engineering. In layout of plant adequate space shall be provided for access to carry-out operation & maintenance of equipment's.

The Scope of work fully covers requirements of Design criteria and technical requirements of the specifications for treating water production as mentioned above (Groups A, B, C, and D). The scope of work includes but not limited to the following:

(1.1.) Chlorine-Dioxide System for "Group A" R.O. (Potable Water) from Doha Distillation Plant Water Flow-rate: 120 MIGD

a) 1 x 100% Sodium Chlorite (25% conc.) bulk storage tank
b) 1 x 100% Hydrochloric Acid (32% conc.) bulk storage tank
c) 2 x 100% Sodium Chlorite unloading pumps (duty/standby) with motors and all accessories.
d) 2 x 100% Hydrochloric Acid unloading pumps (duty/standby) with motors and all accessories.
e) 2 x 100% Motive water transfer pumps (duty/standby) with motors and all accessories.
f) 2 x 100% water storage tanks with related instruments (2 no's of motorized valves on inlet of water storage tanks, 2 set of level switches and level gauges – 2 no's)
g) 2 x 100% reagent dosing skids (one duty/one standby) each skid consisting of 2 x 100% dosing pumps and accessories.
h) 2x 100% submerged under water (option ≠ 1) & under vacuum type (option ≠ 2) chlorine dioxide generators (duty/standby)
i) 6 No's x 100% (4 duty/ 2 standby) chlorine dioxide dosing pumps for 4 No's R.O. (potable water) mains (1-4).
j) 16 No's x 100% sampling pumps (pre-post sampling) with motors & accessories, related pipe work, electrical and control work.
k) 8 No's of chlorine dioxide analyzers/monitoring system for pre & post sampling complete with sampling pipe work, instrumentation & control.
l) 1 no. of local control panel for serving chlorine dioxide generating & dosing duty/standby equipment's.
m) 1 no. general electrical panel serving chlorine dioxide system
n) 4-sets of safety showers, eye wash & accessories
o) Pipe works relating to ClO_2 system
p) Sets of ClO_2 solutions piping, fitting, valves etc. from generator + dosing point complete with 4 x 100% injection diffuser assembly as shown in tender drawing.
q) Electrical, control & instrumentation required within the system
r) Erection & commissioning, PG test and handing over
s) 1 set of mandatory spares

t) Operation chemical ($NaClO_2$ and HCl) as per contract.

(1.2.)Chlorine-Dioxide System for "Group B" (FW) Coming from Subiya WDC (via 3 No's Mains 1200 mmDIA) **Water Flow-rate: 100 MIGD**

a) Items (a,b,c &d) of "Group A" are common for "Group B"
b) Item "f" of "Group A" is common for "Group B"
c) 2 x 100% Motive/dilution water pumps (duty/standby) with motors & accessories
d) 2 x 100% reagent dosing skids (duty/standby) each skid consisting of 2 x 100% dosing pumps and accessories with motors & accessories
e) 2 x 100% submerged under water (option ≠ 1) & under vacuum type (option ≠ 2) chlorine dioxide generator (duty/standby)
f) 1 No. x 100% LCP for ClO_2 generating/dosing
g) 1 No. general electrical panel for ClO_2 system.
h) 4 No's x 100% (3 duty / 1 standby) ClO_2 dosing pumps with motor & accessories for 3 No's of FW incoming lines from Subiya WDC to Mutla High WDC. Pumps should be complete with pipe-works, electrical works and accessories etc.
i) 6 No's x 100% chlorine dioxide analyzer/monitor & accessories complete with pipe-works, electrical and control work.
j) 12 No's x 100% sample pump with motors & accessories complete with pipe-works, electrical/control work.
k) Complete pipe-work relating ClO_2 generating/dosing system
l) 3 x 100% set of ClO_2 solution pipe-work, tie-in work on existing injection assembly in existing injection chambers as shown on tender drawing
m) Electricals, control/instrumentation required within the system
n) Erection & commissioning, PG test and handing over
o) 1 set of mandatory spares
p) Operation chemicals (HCl & $NaClO_2$) quantities as per contract specifications.

(1.3.) Chlorine-Dioxide System for Treatment "Group C" 3 x 1200mm DIA (FW) Pipeline out-going to West Funaitees Reservoirs WDC **Water Flow-rate: 100 MIGD**

a) Items (a,b,c &d) of "Group A" are common for "Group C"
b) Item "f" of "Group A" is common for "Group C"
c) 2 x 100% Motive/dilution water pumps (duty/standby) with motors & accessories
d) 2 x 100% reagent dosing skids (duty/standby) each skid consisting of 2 x 100% dosing pumps and accessories with motors & accessories
e) 2 x 100% submerged under water (option ≠ 1) & under vacuum type (option ≠ 2) chlorine dioxide generator (duty/standby)
f) 1 No. x 100% LCP for ClO_2 generating/dosing
g) 1 No. general electrical panel for CLO2 system.

h) 4 No's x 100% (3 duty / 1 standby) ClO_2 dosing pumps with motor & accessories for 3 No's of FW outgoing lines from Mutla High WDC to West Funaitees Reservoirs. Pumps should be complete with pipe-works, electrical works and accessories etc.
i) 6 No's x 100% chlorine dioxide analyzer/monitor & accessories complete with pipe-works, electrical and control work.
j) 12 No's x 100% sample pump with motors & accessories complete with pipe-works, electrical/control work.
k) Complete pipe-work relating ClO_2 generating/dosing system
l) 3 x 100% set of ClO_2 solution pipe-work, tie-in work on existing injection assembly in existing injection chambers
m) Electricals, control/instrumentation required within the system
n) Erection & commissioning, PG test and handing over
o) 1 set of mandatory spares
p) Operation chemicals (HCl & $NaClO_2$) quantities as per contract specifications.

(1.4.) Chlorine-Dioxide System for Treatment "Group D" MAINS (Water flow rate in 3 No's of inlet/outlet of Reservoirs **Water Flow-rate:**

- **1200mm DIA inlet line from Doha (P10) to Mutla High WDC** 30 MIGD
- **1200mm DIA outlet from Mutla High WDC to Jahra** 30 MIGD
- **1000mm DIA outlet for Mutla High WDC to Mutla Low/Abdaly** 15 IGD

a) Items (a,b,c &d) of "Group A" are common for "Group D"
b) Item "f" of "Group A" is common for "Group D"
c) 2 x 100% Motive/dilution water pumps (duty/standby) with motors & accessories
d) 2 x 100% reagent dosing skids (duty/standby) each skid consisting of 2 x 100% dosing pumps and accessories with motors & accessories
e) 2 x 100% submerged under water (option ≠ 1) & under vacuum type (option ≠ 2) chlorine dioxide generator (duty/standby)
f) 1 No. x 100% LCP for ClO_2 generating/dosing
g) 1 No. general electrical panel for ClO_2 system.
h) 4 No's x 100% (3 duty / 1 standby) chlorine dosing pumps with motor & accessories for 2 No's of FW outgoing lines from Mutla High WDC to Jahra and Abdaly. And 1 No. of fresh water line incoming from Doha (P10) to Mutla High WDC. Pumps should be complete with pipe-works, electrical works and accessories etc.
i) 6 No's x 100% chlorine dioxide analyzer/monitor & accessories complete with pipe-works, electrical and control work.
j) 12 No's x 100% sample pump with motors & accessories complete with pipe-works, electrical/control work.
k) Complete pipe-work relating ClO_2 generating/dosing system
l) 3 x 100% set of ClO_2 solution pipe-work, tie-in work on existing injection assembly in existing injection chambers as shown on tender drawing
m) Electricals, control/instrumentation required within the system

n) Erection & commissioning, PG test and handing over
o) 1 set of mandatory spares
p) Operation chemicals (HCl & $NaClO_2$) quantities as per contract specifications.

Items though not mentioned but needed to make the system complete as stipulated under these specifications are also to be furnished unless otherwise specifically excluded.

(1.5.) General Condition:

- It is not the intent to specify all the details of the design & manufacture. However, the equipment shall conform in all respects to high standard of design, engineering and workmanship and shall be capable of performing the required duties in a manner acceptable to Engineer / Customer, who will interpret the meaning of drawing & the specification and shall be entitled to reject any work or material, which is not in full accordance herewith.
- In case of any deviation, the Bidder shall indicate the same, clause by clause in the deviation schedule. In the absence of the same it will be construed that the bid confirms strictly to the specification.
- General terms & conditions, instructions to the bidder & other attachments referred to elsewhere are part of this specification.
- The order of priority of this specification is as follows:
  a. Technical requirement/Equipment Specification,
  b. Drawings
  c. General design requirements
- Any contradiction either between various parts or contents of the specification shall be a matter for clarification to be obtained by the bidder. The Customer's decision shall be final. However, as a general guideline the details furnished in the Equipment specification shall prevail.
- The material shall be dispatched to site as per the bidder's shipping list approved by customer. The format for the shipping list & quality plan will be given by customer after order for the successful bidder.

(1.6.) PROJECT - INFORMATIONS

Owner:	Ministry of Electricity & Water (MEW)
Project Title :	Construction &Maintenance of 5 No's RC Reservoirs and Water Treatment Plant and Annexed Works at Mutla High WDC-II.
Location:	MUTLA HIGH WDC-II KUWAIT.

(1.7) Water Treatment Disinfection)

(a) On-site Chlorine dioxide generation/dosing system is required for disinfecting the potable water (FW).

(b) Fresh water from storage reservoir before delivering to networks & other water storage zone is treated with ClO_2 for disinfection purpose.

(1.8) Arrangement of Plant

The contract drawing shows the details of the ClO_2 treatment system equipments and the proposed lay-out of equipments if any departures from the arrangement shown are necessary for efficient working of the plant proposed. The tenderer shall give full details in the tender and shall show this suggested modification of drawings submittal with this offer.

(1.9) Water Quality

(1.9.a) General.

The water quality data and supplementary information given herein are to assist the contractor at time of tendering such information shall deemed to be information provided by or on behalf of the employer the information is not warranted and contractor shall make use of and interpret the same as his own responsibility.

(1.9.b) Fresh (Potable) Water Quality

Projected Water Quality & Fresh (Potable) Water

Parameters	Fresh Water Subiya
Temperature (^{0}C)	27 - 47
pH	8.1
Conductivity (µs/cm)	203
Total Dissolve Solid (mg/l)	107
Residual Chlorine (mg/l)	0.55 *
Total Alkalinity (mg/l)	52
Carbon Dioxide (mg/l)	1.5
Total Hardness (mg/l)	80
Calcium Hardness (mg/l)	60
Magnesium Hardness (mg/l)	20
Chloride Ion (mg/l)	24
Ammonia (mg/l)	NIL
Silica (mg/l)	1.0
Nitrate (mg/l)	
Sulphate (mg/l)	
Phosphate (mg/l)	
Iron (mg/l)	
Potassium (mg/l)	
Nickel (mg/l)	
Bromide (mg/l)	
Bromate (mg/l)	
Turbidity (NTU)	0.3
Mono chloramine (mg/l)	NIL

(1.9.c) DILUTION WATER QUALITY (R.O) Potable Water

Water Parameter(s)	Min - Max
a) TDS :	~300 ppm
b) TSS :	10 - 50 ppm
c) Temp :	$30^0C – 47^0C$

(2.0.)On site Chlorine Dioxide Generating Plant " Under Water & Under Vacuum Type"

(2.a) General

Chlorine dioxide should be generated by using sodium chlorite(25% conc $NaClO_2$ Food grade) & hydrochloric acid (32% HCl) Food grade for disinfecting the potable water/FW

Chemical Aspect

Chlorine dioxide generated by following chemical reaction

$5NaClO_2 + 4HCl \longrightarrow 4\ ClO_2\,(g) + 5NaCl + 2H_2O$

(2.b) Chemicals and Chlorine Dioxide Dosages

Raw – Material

Sodium Chlorite ($NaClO_2$) : 25%Conc Food - grade

Hydrochloric Acid (HCl): 32% Conc. Food - grade

The chlorine dioxide (ClO_2) plant should be capable of generating chlorine dioxide sufficient to disinfect FW having yield of about 98% Design capacity ClO_2 generating unit should match with MAX flow rate in each inlet/outlet lines as mentioned in is specification. Chlorine-dioxide disinfection system for inlet/outlet lines of reservoirs should be separate groupwise duty/standby system as mentioned in the specifications

(2.c)Chlorine-Dioxide (ClO_2) System Capacity

The plant should meet the requirement as indicated in below Table:

No. of Streams	Description	Capacity of each Generator
Group A	4 No's inlet lines 1200mm DIA from Doha Distillation plant to Mutla High WDC	20 KG/HR of ClO_2
Group B	3 No's inlet lines 1200mm DIA from Subiya	

	WDC to Mutla High WDC	20 KG/HR of ClO_2
Group C	3 No's outlet line 1200mm DIA from Mutla High WDC to West Funaitees WDC	20 KG/HR of ClO_2
Group D	1 No. inlet 1200mm DIA from Doha (P10) to Mutla High WDC 1No. outlet 1200mm DIA from Mutla High WDC to Jahra (D20) 1No. Outlet 1000mm DIA from Mutla High WDC to Mutla Low and Abdaly.	10 KG/HR of C ClO_2

(2.d)<u>List of Chlorine dioxide dosage rates at various dosing points</u>

Ref	**Dosing Point**	**Disinfectant**	**Estimated dosage mg/l**	
			Average	**Max**
R.O (Potable Water) from Doha (Dist. Plant)	1200mm DIA inlets of Reservoirs	Chlorine- dioxide	0.25 mg/l	0.8mg/l
	Line # 1			
	Line # 2		0.25 mg/l	0.8mg/l
	Line # 3		0.25 mg/l	0.8mg/l
	Line # 4		0.25 mg/l	0.8mg/l
FW from Subiya WDC	1200mm DIA inlets of Reservoirs	Chlorine- dioxide	0.25 mg/l	0.8mg/l
	Line # 5			
	Line # 6		0.25 mg/l	0.8mg/l
	Line # 7		0.25 mg/l	0.8mg/l
FW from Mutla High WDC to West Funaitees Reservoir	1200mm DIA inlet ofReservoir	Chlorine- dioxide	0.25 mg/l	0.8mg/l
	Line # 8			
	Line # 9		0.25 mg/l	0.8mg/l
	Line # 10		0.25 mg/l	0.8mg/l
FW incoming & outgoing from Mutla High Reservoir site	1200mm DIA inlets from Doha (P10) Line # 11	Chlorine- dioxide	0.25 mg/l	0.8mg/l
	1200mm DIA outlet to Jahra Line # 12		0.25 mg/l	0.8mg/l
	1000mm DIA outlet to Abdaly Line # 13		0.25 mg/l	0.8mg/l

(2.e)Pressure Rating at ClO_2Dosing Points in Pipe lines

Water pressure available at inlet/outlet of Reservoirs at injection points as follows:

- 4 No's 1200mm DIA inlet lines - Doha RO (Potable) water = 14.7 M
- 3 No's 1200mm DIA inlet lines - Subiya (Potable) water = 10 M
- 3 No's 1200mm DIA outlet lines - Multa High to West Funaitees = 5 M
- 1 No. 1200mm DIA outlet line - Mutla High to Jahra = 5M
- 1 No. 1200mm DIA outlet line – Mutla to Abdaly = 5M
- 1 No. 1000mm DIA Inlet line – Doha(P10) to Mutla High = 5M

(2.1)TECHNICAL SPECIFICATION - MECHANICAL

(2.1.1) Design Criteria

- Operation of Chlorine Dioxide generator shall be completely automatic through PLC (Redundancy) system. Bidder shall render all technical assistance in implementing the sequential operation of their system with the PLC system (1 duty/1 standby) in LCP.
- Bidder to draw Dilution water from water tank. Water will be made available from 4 Nos of RO lines via 400mm dia D.I pipeline to water tank outlet nozzle. Bidder to pump dilution water from water tank nozzle to Chlorine dioxide generator using Dilution water transfer pumps.
- HCl (32%) and $NaClO_2$ (25%) from IBC-Containers shall be unloaded to respective Bulk storage tanks using unloading pumps (Bidder's scope).
- Required quantity of HCl and $NaClO_2$ shall be dosed for usage in chlorine dioxide generator using respective dosing systems.
- Chlorine dioxide dosing shall be done as continuous average basis @ free residual chlorine dioxide of 0.25 – 0.4ppm in potable / drinking water.
- Necessary piping, pneumatic and manual operated valves, instruments, controls & interlocks shall be provided in the system for auto operation and also as per the P & ID (Process & Instrumentation Diagram) drawing enclosed with this specification. Instrumentation shown in the P&ID is minimum requirement. List of minimum instrumentation required are specified in a separate clause in this specification.

(2.1.1.a) Dilution Water Cooling System for ClO_2 Generator (Provisional Item)

Air- cooled chiller unit (heat exchanger type) should be provided for cooling the dilution water temperature from47°C to 25°C used in ClO_2 generating system.
Technical detail of cooling water system are mentioned in tender specification section (HVAC)

Dilution motive water

Flow-rate	40 m^3/hr
Dilution water temperature	47°C
Chilled water temperature	25°C

The contractor has to follow the detailed specification of the required cooling system mentioned in HVAC section of the tender document.

(2.2.)Terminal Points:

a. Dilution water will be made available at water tank outlet nozzle (DN100) with flange having drilling standard ANSI B16.5 150lbs. Complete scope of work from terminal point up to the ClO_2 system is required.
b. Acid (32% HCl) required for Chlorine dioxide generator shall be made available once in 15 days by the contractor for a period of two years regular basis as per contract specifications. Bidder to provide unloading pumps along with suction piping for drawing HCl from IBC-Container and storing in Bulk HCl storage tank and further use.
c. Sodium Chlorite (25% NaClO2) required for Chlorine dioxide generator shall be made available in $NaClO_2$ once in 15 days by contractor for period of two years on regular basis as per contract requirement. Bidder to provide unloading pumps along with suction piping for drawing $NaClO_2$ from IBC Container and storing in Bulk $NaClO_2$ storage tank and further use.
e. The entire scope of Chlorine dioxide generation and dosing system shall be under Bidder's scope of work as per tender conditions. Power cables and electrical equipment's (MCC, MSB & Circuit breaker etc.) for all the drives should be provided at the terminal box of respective motors. Tenderer should provide the drives list in their offer. Power supply shall be 415 V, 3 phase supply. Control cables, Instruments and instrument cables should be provided by the contractor complete with junction box of individual skid / system. The contractor should also provide cables from Junction box up to PLC/LTMCC panel etc. The necessary civil works like equipment foundation with pockets, trenches, dyke walls, kerb wall are included in the scope of work. The contractor has to follow the scope of work as mentioned in the civil specifications and tender drawings.
f. Chlorine dioxide system (Chlorine dioxide generator with valves, piping & headers, pumps and rest of the equipment) equipment should be accommodated by the bidder within the given space / building. No additional space will be provided. Bidder should provide the detailed arrangement layout drawings along with the bid. Complete pipe work should be completed as per approved drawings of ClO_2 system.

(2.3.)Dilution Water Supply (Scope of Work)

- Required complete pipe-work (D.I) for taking water supply from 4 No's of R.O (Potable water) lines in water take-off/pre-sampling chamber.
- Tapping points DN100 side entry of RO Pipe lines (1-4) with SS-316L isolating valves DN100.
- The Water supply from each tie-in point on R.O main pipelines should be complete with isolating valves & air release valves, the water supply from 4 tie-in points DN100 should

be connected to 400mm DIA D.I common header feeding to daily water tanks or direct to ClO_2 generating system.

- 2 Nos. Of FW water tanks of material GRP capacity of each (2000 Gallons) complete with in/out pipe- works, are required.
- Water supply to water tank include Tie-in on RO potable water inlet of reservoirs as shown on tender drawing, complete with pipe works from Tie-in point up- to dilution water tanks.
- 1 Set (Duty / Standby) water pump, filling pump required to fill these water tanks with complete valve fitting for filling system.
- 1 Set (Duty/Standby) water pump required at outlet of these tanks for pumping water to "Under water or under-vacuum type" ClO_2 generators (Reaction chambers) as shown on tender drawings.
- For water tanks & water Pumps complete instrumentation (e.g.) Float, Flow switches, Solenoid valves, Valves, Level, Sensors & necessary gauges, pipe works required for complete installation of work.
- Power supply cabling to pumps, Control cables & signal cables connections, termination from main power source to general electrical & LCP panels are to be completed.
- The dilution water before to reach "Under water or under-vacuum type" ClO_2 generators (Reaction chambers) is stored in Two dedicated tanks (2000 Gallons each) in order to guarantee continuous water feeding during the reaction. Tanks are automatically refilled with potable water by opening / closing of the fresh water inlet valve.

(2.4.)EQUIPMENT SPECIFICATION:

The technical requirement of the equipment is indicated below. In addition, the applicable P & ID and Layout enclosed with this specification shall be referred.

(2.4.1.)ClO_2 DILUTION PUMPS WITH MOTOR & ACCESSORIES:

1) No. of Pumps (for group A, B, C&D of Water streams): 2 x 100% for 4 Group = 8Nos.
2) Location : pump room
3) Operation : Continuous
4) Type : Horizontal centrifugal
5) MOC
   - Casing, Impeller& Stuffing Box : Carbon Steel, SS316L
   - Shaft : SS 316L
6) Make : As per Mech.Vendor list
7) Speed of the pump : 1500 rpm
8) Design Flow /pump : 26 m3/hr (min.) bidder to decide
9) Design Head of pumps : As per system requirement + friction head for design flow of the pump. The system requirement should match with the hydraulic calculation taking into consideration the water pressure at the point of application of the stream.
10) Bearing : Anti-friction
11) Seal : Gland packing

12) Lubrication	: bidder to specify
13) Coupling	: Flexible & spacer type
14) Operating range	: 30 – 120% of rated flow
15) Pump characteristic	: Non-overloading type & stable
17) Shut-off head	: About 15 % more than the rated head
18) MOC of All fasteners	: GI
19) Accessories	: a) Anchor bolts, nuts sleeves & Inserts to be embedded to concrete. b) Drain plug, vent, coupling guard lifting lugs etc.
20) Motor	: As per tender specification.
21) Motor rating (Max.)	: 15 KW

(2.5.)Chlorine Dioxide System Description

- The chlorine dioxide system should be designed for generation of chlorine dioxide solution as stated in the Item 1.1 of page 4 tender documents for disinfection of potable water.
- Conc. of Chlorine dioxide at injection should be 0.5 – 2 g/l. The contractor should submit the calculation from the manufacturer of the chlorine dioxide generating plant normal & max dosage rates at min/max water production rates as mentioned in the specification.

- **Reagents Unloading & Storage Section for Inlet & Outlet of Reservoirs.**

Two tanks for raw chemical ($NaClO_2$ & HCl) capacity of each suitable to cover required demand for Max water which is to the treated, these to be installed in separated retention basins. Two loading pumps for each storage tank with different connection (bigger for HCl) should be installed for reagents loading operation. Complete pipe work, valves & fitting required for intake (filling point) to HCl & $NaClO_2$ storage tanks with R.C foundations for loading pumps and storage tanks.

- **Chlorine Dioxide Production Section Inlet & Outlet of Reservoirs**

Each reagent dosing Skid is composed of 2 Nos. (1duty/1standby) of HCl dosing pump, and 2 Nos. (1duty/1standby) of $Naclo_2$ dosing pump each is gravity supplied from the related storage tanks. The production of ClO_2 solution carried out with two dedicated ClO_2 generators.
Each generator can work with both of the reagent dosing Skids. Each pump of the Skids, by means of three- way valve (Positioned on pump discharge line) can convey the reagent to the selected ClO_2 generators. Each Skid can send both reagents to same ClO_2 generators at the time. Each reagent dosing Pump should be designed to give flow rate to produce

necessary quantity of ClO_2.

- **Chlorine Dioxide Dosing Section Inlet & Outlet of Reservoirs.**

  - 18 Nos. of complete dosing pumps (13 Duty / 5 Standby) serving 13 Nos. of ClO_2 injection points on inlet/outlet of reservoir as shown in the tender drawings.
  - Dosage can be controlled Man / Auto
    Man – on water flow rate (Water Production)
    Auto (Compound loop) by flow rate and ClO_2 signal.

- The reagents are to be stored in dedicated storage (Chemical Storage building) and ClO_2 dosing pumps inside pump room. The reagents should be supplied in bulk at following concentration.

- Hydrochloric Acid : 32%
- Sodium Chlorite : 25%

(2.5.1.)TheDesign Data of Main Equipments.
(2.5.2.)Hydrochloric Acid 32% Storage Tank.

1. Tank : Bulk acid storage
2. Medium used : 32% Hydrochloric acid
3. Location : Outdoor
4. Quantity : 1 no.
5. Capacity (usable volume) : 15 days requirements for total production (R.O Doha + Subiya Portable = 220MIGD at.Avg. ClO_2 Dosage rate 0.25 ppm (as mentioned in tender Specifications)
6. MOC : GRP or FRP (Vinyl ester resin) with UV protection
7. Type : Horizontal, cylindrical with dished ends
8. Pressure : Atmospheric
9. Tank dia. : 2.5m (min.) (inside)
10. Tank thickness : 10mm (min.) the glass content of inner layer shall be 25 to 30% by weight. The glass content of filament wound structural layer shall be 55 to 70 % by weight.
11. Piping, valves & fittings : CPVC, PN16
12. Tank nozzle flange thickness :15mm (min.)
13. Accessories : Each tank consist of necessary manholes inlet/ outlet/ drain & vent nozzles, piping, valves, access ladder with safety cage, top platform, hand rails for manhole access safety showers, eyewash etc. Suitable handling arrangement/lifting lugs are to be provided in the tank for easy movement.

14. Instruments : Level transmitters (radar type), Level Indicators, manual level gauge, Density Indicator

15. The tank should be supplied along with support saddle with flat bottom so that it can be mounted on concrete pedestal.

16. Design Code : BS 4994 or equivalent

17. Additional nozzle with valves (2nos.) of DN50

Tank should be complete with

- 1 No. of membrane- type transmitter complete with isolating valve.
- 1 No. of level gauge with level switch.
- Sealing pot (Scrubber) for the dilution of HCl fumes, operating with fresh water, material GRP.

Tank should be positioned in a dedicated containment basis, made of reinforced concrete protected by anti-acid epoxy coating.

Note: Height of the pedestals shall be 1.0m from FGL

(2.5.3.)<u>Sodium Chlorite 25% Storage Tank.</u>

1. Tank : Bulk $NaClO_2$ storage
2. Medium used : 25% $NaClO_2$
3. Location : Outdoor
4. Quantity : 1 no.
5. Capacity (usable volume) : 15 days requirements for total production 220MIGD at.Avg. ClO_2 Dosage rate 0.25 ppm (as per mention in tender specifications)
6. MOC : GRP or FRP (Vinyl ester resin) with UV protection
7. Type : Horizontal, cylindrical with dished ends
8. Pressure : Atmospheric
9. Tank dia. : 2.5m (min.) (inside)
10. Tank thickness : 10mm (min.) the glass content of inner layer shall be 25 to 30% by weight. The glass content of filament wound structural layer shall be 55 to 70 % by weight.
11. Piping, valves & fittings : CPVC, PN16
12. Tank nozzle flange thickness : 15mm (min.)
13. Accessories : Each tank consist of necessary manholes inlet/ outlet/ drain & vent nozzles, piping, valves, access ladder with safety cage, top platform, hand rails for manhole access safety showers, eyewash etc. Suitable handling arrangement/lifting lugs are to be provided in the tank for easy movement.
14. Instruments : Level transmitters (radar type), Level Indicators, manual level gauge, Density Indicator
15. The tank should be supplied along with support saddle with flat bottom so that it can be mounted on concrete pedestal.
16. Design Code : BS 4994 or equivalent

Tank should be complete with

- 1 No. of membrane - type transmitter complete with isolating valve.
- 1 No. of level gauge with level switch.

Tank should be positioned in a dedicated containment basis, made of reinforced concrete.

Note: Height of the pedestals shall be 1.0m from FGL

(2.5.4.) A.32% Hydrochloric Acid Unloading Pumps with Motor & Accessories:

1. No. of pumps : 2 X 100% (duty/Standby) complete with pipe-work, suction/discharge Pressure gauges & accessories
2. Application : To unload liquid HCl of 32% Conc. Solution from IBC- container
3. Duty : Dis-continuous
4. Location : Outdoor
5. Discharge Flow { Should match with
6. Discharge Head { Optimum design requirements }
7. Suction : From IBC-Container
8. Operation : Intermittent
9. Type : Horizontal centrifugal, Electromagnetic or Pneumatic
   - i) Casing : PP/PVDF
   - ii) Impeller : Teflon
   - iii) Seal/packing : Single mechanical seal-API plan-11
   - iv) Shaft : EN8
   - v) Shaft sleeve : Ceramic
10. Speed of the pump : 1500rpm
11. Bearing : Anti-friction
12. Coupling : Flexible (spacer type) with guard
13. MOC of all fasteners : SS316/better; to suit the environment
14. Base frame for pump & Motor mounting : Carbon steel with epoxy coated
15. Accessories : Suction pipe/rigid hose 20m minimum, suction strainer (Y-type), drain & vent valves, delivery piping to storage tank and flushing arrangement piping for the flushing of the pump after unloading the chemical etc. The operation of the pump shall be controlled by the level switch in the tank (pump shall be stopped before the tank overflows)
16. Valves & strainers : CPVC, PN16
17. Motor : As per specification

Note: For the Pneumatic type air compressor should be provided to supply pneumatic air complete with pipe work, power supply & installation included other work required for supply of pneumatic air to pump.

(2.5.5.) B.25% Sodium Chlorite Unloading Pumps with Motor & Accessories

1. No. of pumps : 2 x 100% complete with pipe-work, suction/discharge Pressure gauges & accessories.
2. Application : To unload liquid $NaClO_2$ of 25% Conc. Solution from IBC-container
3. Duty : Dis-continuous
4. Location : Outdoor
5. Discharge Flow } Should match with
6. Discharge Head } Optimum design requirements
7. Suction : From IBC-Container
8. Operation : Intermittent
9. Type : Horizontal centrifugal, Electromagnetic or Pneumatic
   - i) Casing : PP/PVDF
   - ii) Impeller : Teflon
   - iii) Seal/packing : Single mechanical seal-API plan-11
   - iv) Shaft : EN8
   - v) Shaft sleeve : Ceramic
10. Speed of the pump : 1500rpm
11. Bearing : Anti-friction
12. Coupling : Flexible (spacer type) with guard
13. MOC of all fasteners : SS316/better; to suit the environment
14. Base frame for pump & Motor mounting : Carbon steel with epoxy coated
15. Accessories : Suction pipe/rigid hose 20m minimum, suction strainer (Y-type), drain & vent valves, delivery piping to storage tank and flushing arrangement piping for the flushing of the pump after unloading the chemical etc. The operation of the pump shall be controlled by the level switch in the tank (pump shall be stopped before the tank overflows)
16. Valves & strainers : CPVC, PN16
17. Motor : As per specification

Note: For the Pneumatic type air compressor should be provided to supply pneumatic air complete with pipe work, power supply & installation included other work required for supply of pneumatic air to pump.

(2.6.)Chlorine Dioxide Production Section.

a) Reagent Dosing Unit.

2 sets x100% (Duty / Standby) for inlet & outlet of reservoir site basic reagent skids should be supplied one duty/ one standby.

Each Skid should composed of:

- 1 Set. Hydrochloric acid dosing pump. 1Set = 2Nos. (1duty/1standby)
- 1 Set. Sodium Chlorite dosing pump. 1Set = 2Nos. (1duty/1standby)
- 1 Set. Automatic motorized valves intercepting the suction of the hydrochloric acid pump and the sodium chlorite pump.
- 1 No. automatic three- ways 3 Nos. motorized valves at each discharge line of pump to allow the delivery to (Under water or under vacuum type reaction chamber No.1) or (Reaction chamber No.2)
- Instrumentation
- Each dosing pump is equipped with dedicated basin where leakages are contained.

(2.7.)32% Hydrochloric Acid Dosing Pump (Provisional item in under water type ClO_2generator).

1) No. of pumps	: 2 x 100% (duty/standby) complete with pipe-work, suction/discharge pressure gauge, valves & fitting
2) Application	: Acid (HCl (32%) dosing
3) Duty	: Continuous
4) Type Metering Pump	: Diaphragm
5) Location	: outdoor
6) Stroke adjustment	: manual
7) Dosing concentration &	: 30% (As required) & 1.15specific gravity
8) Design pressure	Match to optimum design requirement as per
7) Pump design flow rate	Specification of the system required
8) Pump suction type	: Flooded
9) Pump housing	:CPVC
10) Diaphragm type	: PTFE

Note: Pump with motor assembly shall be designed to suit 4-20mA signal with stepper motor to accommodate turn down ratio of approximately 1:750.

DOSING SKID:

1) Skid frame	: 1 no.
2) Interconnecting piping & valves	: 1 set
3) Pressure gauge & pressure relief valve	: 1 set
4) Fume absorber	: 1 no.
5) Junction box with terminal box for pump	: 1 no. for each pump
6) Piping system MOC & size	: CPVC industrial grade, PN16 rating, DIN standard or Sch.80 class. All ball valves shall be of union type only.

(2.8.)25% Sodium Chlorite dosing Pump (Provisional item incase of under water type ClO_2 generator & in under vaccum type generator required ejector vaccum unit).

1) No. of pumps : 2 x 100%
2) Application : Sodium Chlorite ($NaClO_2$ (25%)) dosing
3) Location : outdoor
4) Stroke adjustment : manual
5) Duty : Continuous
6) Type Metering Pump : Diaphragm
7) Dosing concentration & : 25% (As required) &1.27 specific gravity
8) Design pressure } Match to optimum design requirement as per design
9) Pump design flow rate } Specification of the system required
10) Pump suction type : Flooded
11) Pump housing :CPVC
12) Diaphragm type : PTFE

From each skid the reagents are conveyed to the "Under water type or under vaccum type " generators (Reaction chamber) by means of a special pipe (one single piece flexible three layer pipe); dedicated pipe for hydrochloric acid and for sodium chlorite are foreseen.

Note: Pump with motor assembly shall be designed to suit 4-20mA signal with stepper motor to accommodate turn down ratio of approximately 1:750.

DOSING SKID:

1) Skid frame : 1 no.
2) Interconnecting piping & valves : 1 set
3) Pressure gauge & pressure relief valve : 1 set
4) Junction box with terminal box for pump : 1 no. for each pump
5) Piping system MOC & size : CPVC industrial grade, PN16 rating, DIN standard or Sch.80 class. All ball valves shall be of union type only.

(2.9.)Chlorine Dioxide "Under Water (option ≠ 1) Under-Vacuum (option ≠ 2) Type" Generators (Reaction Chambers)

The production of ClO_2 is carried out with dedicated ClO_2 generators (Nos. 2x100%) submerged water under & under vacuum type generator each ClO_2 generator should be designed for maximum ClO_2 dosage rate 0.8 mg/l at maximum water flow rate in each inlet & outlet of reservoirs site (1,2 & 3 lines as mentioned in specification & shown on tender drawings). The ClO_2 generator should be located in chemical building (generator room).

CHLORINE DIOXIDE GENERATOR SKIDS:

1) No. of Skids (for group A, B, C & D of water streams) : 2 x 100% for 4 groups= 8 Nos
2) Location : in chemical building ClO_2 generator room
3) Type : ClO_2 generator unit mounted on an enclosed Skid, Submerged/ underwater or under vacuum type
4) Net output capacity / skid : 20 kg / hr
5) Minimum conversion efficiency : >90 % with respect to ClO_2 yield
6) MOC of ClO_2 reactor : fibreglass/PVC
7) MOC of ClO_2 solution line : CPVC
8) General:

a. Feed reagent filters shall be provided on the inlet lines to the chlorine dioxide generator unit.

b. Air contact with chlorine dioxide solution should be controlled to limit the potential for explosive concentrations possibly building up within the reactor.

c. Necessary supports for the piping shall be provided by the bidder.

d. The skid MOC shall be of carbon steel with painting having sufficient strength and rigidity to support the equipment contained in the skid epoxy painted.

9) Following controls shall be provided with the following instruments & controls as a minimum:

i. pH in Chlorine dioxide solution dosing line
ii. Residual chlorine dioxide (ClO_2) analyzer
iii. Flow meters on all chemical feed lines, dilution water lines, and chlorine dioxide solution lines.
iv. Pressure indicator & controller on the water inlet line to ClO2 generators, chlorine dioxide dosing controller, low vacuum switch, solenoid valves, etc., all complete and as required shall be provided.
v. The dosing in inlet& outlet lines of reservoirs shall be automatically controlled based on water flow rate & the signal received from residual chlorine dioxide analyzer in the header
vi. All chemical storage tanks shall have automatic high and low level cut off.
vii. Chlorine dioxide leak detection system.
viii. In case of water supply to the generator stops, the chemical dosing pumps shall also stop automatically.
ix. Generator must be equipped with systems of dosing and/ or measurement for reagents and diluting water. These systems must be able to shut down the operation of the generator in case any of the supplies is cut off.

(3.0.)TheDosing Skids (For Inlet/Outlet of Reservoirs)

The Chlorine dioxide solution should be carried out by dosing facilities dedicated for each injection point in each ClO_2 injection chamber for each inlet & outlet of reservoirs.

- Group A : 6 No (4 duty/2 standby) ClO_2 dosing pumps
- Group B : 4 No (3 duty / 1 standby) ClO_2 dosing pumps
- Group C : 4 No (3 duty / 1 standby) ClO_2 dosing pumps
- Group D : 4 No (3 duty / 1 standby) ClO_2 dosing pumps
- Duty : Continuous
- Type : As per system design
- Flow rate : Should match with required dosage rate
- Head : Demand as mentioned in tender specification
- Flow meters should be installed on each discharge line of the dosing pump and signals should be transferred on LCP and DAC system.
- Flow control valve should be installed to control the chlorine-dioxide flow rate to injection point as per the system requirement.
- Complete pipe-work, pressure gauges, valves & fitting included in scope of work.

(3.1.)<u>Pipe Works Piping and Valves Material.</u>

To dosing, supply, install, test, commission /operate/ maintain on site ClO_2 generators /dosing system related pipe works complete in all respect.

- All pipe works in contact with reagents or FW water within the reagent skids inside conditioned dedicated area should be of CPVC.
- All pipe work in contact with reagents outside ClO_2 generating unit, pipes, valves& inside R.C. trenches, fittings relating FW water supply, & sampling lines should be of CPVC with standard color code.
- All the pipes works (Pipes, valves & fittings) conveying the reagents from dosing station to reaction chambers of CPVC and chlorine dioxide solution to injection points should be made of CPVC.
- Sizing of pipe-work should match with design hydraulic data of the system required.
- R.C. trenches for ClO_2 solution , injection, water supply & sampling lines between injection /sampling water take off points chamber up to ClO_2 dosing plant & analyzer room should be constructed R.C. trenches to be connected to existing trenches where ever required as shown on tender drawings.
- Sizes of pipelines shall be selected such that the velocity of fluid in pipes does not exceed the following limits under conditions of maximum possible volumetric flow:

  - Pump Suction: <1.2 m/sec
  - Pump Delivery & header: ≤ 2 m/sec
  - Service water / Potable water: ≤ 2 m/sec
  - Compressed air: 15 m/s

- All high points in piping system segments shall be provided with air vents along with valves. All low points in piping segments shall be provided with drains along with valves.
- Compressed air pipe work shall be adequately drained to prevent internalmoisture accumulation and moisture traps shall be provided at strategic locationin piping system.
- Necessary thrust blocks shall be provided to minimize water hammer & vibration in piping & headers.
- Supporting arrangement of piping system shall be rigid and properly designed for systems where hydraulic shocks and pressure surges may arise in the system during operation.
- Sufficient upstream and downstream lengths shall be provided for flowmeasuring device, control valves and other specialties.
- Test certificate / compliance certificate to be furnished by the bidder for all the components instruments & piping etc.

(3.2.)MATERIALS OF CONSTRUCTION:

S.No.	SERVICE	SIZE	PIPES	FITTINGS	FLANGES	GASKETS	LINE JOINT
1.0	**Low Pressure Application**						
1.1	Dilution water pump suction & Discharge	Upto DN 100	CPVC , PN16 as per latest DIN standard	CPVC , PN16 as per latest DIN standard	UPGF / PP Flange drilling should be ANSI B16.5, 150 Class	Neoprene rubber gasket	Solvent cemented / flanged
1.2	Instrument Air & Plant Air line	All sizes	Galvanized as per IS 1239 , Heavy grade	Screwed fittings of Galvanized as per IS 1239 , Heavy grade	Not applicable. Screwed fitting shall be considered	Not applicable	Screwed Connections
1.3	Chemical dosing lines (HCl & $NaClO_2$)	All sizes	CPVC, Sch.80 of ASTM	CPVC, Sch.80 of ASTM	UPGF / PP Flange drilling should be ANSI B16.5, 150 Class	Viton rubber gasket	Solvent cemented / flanged
1.4	ClO2 solution dosing line	All sizes	HDPE/ uPVC, PN16	HDPE/ uPVC, PN16	HDPE/ PP-GF	Viton rubber gasket	Solvent cemented / flanged

(3.3.)SamplingSystem

Pre and post disinfection samples to be provided:

The schedule below lists the locations of the sample abstraction points and the instruments or sample taps to be served. Each sample abstraction point shall be provided with a local sample tap complete with sink and a drain discharging to the site drainage system. Where sample points

are located close together samples may be brought to a common sample sink in the vicinity of the sampling points. Additionally each sample shall be conveyed to the laboratory. One or more sample sinks designed for continuous flow of sample shall be provided. Each sample tap shall be appropriately labelled. The installation shall include for making the abstraction points and providing, installing and fixing all necessary pipe work, valves and a sample taps.

Wherever possible samples shall be taken under the hydrostatic head of the system at the sampling point. When pumping is necessary, the contractor shall take care in the selection of pumps, fitting and system design to ensure the physical and chemical characteristics of the samples are not altered during sampling.

Sampling pumps shall be provided in duplicate (one duty, one standby). Automatic changeover from duty to standby pump in the event of the failure of the duty pump is not required. The failure of the duty pump shall be annunciate as the pump fault and sample failure.
The location of water quality monitoring instruments in relation to the sample abstraction point and size of pipe work shall be according to the needs of the monitoring unit supplied and where applicable to give the required process time for efficient close loop control.

All sample supplies to water quality instrument shall be fitted with sample flow monitors arranged to initiate sample flow low alarm.

- Monitoring units shall be mounted in the proximity of the abstraction points and the local sample taps shall be located adjacent to the monitoring units. Monitoring units located outdoors shall be enclosed in weather-proofed cabinets. Location of monitoring units shall be as indicated on the drawings
- Sampling Pipe-works for sampling pipelines from tapping points (at main outlet / lines of reservoir) up to ClO_2 analyzer in (analyzer room) should be complete in all respect.
- All ClO_2 solution Pipe-works from ClO_2 generating unit up to injection points to be complete in all respect.

(3.4.)<u>Schedule of Water Sampling Quality/ Control</u>

Sample Point	Sample Description	Parameter measured		Function MC	
		Pre - Sampling	Post - Sampling		
S 1	4 No's inlet lines 1200mm DIA from Doha Distillation plant to Mutla High WDC	Residual Chlorine di-oxide	Residual Chlorine di-oxide	M	MC
S 2	3 No's inlet lines 1200mm DIA from Subiya WDC to Mutla High WDC	Residual Chlorine di-oxide	Residual Chlorine di-oxide	M	MC
S 3	3 No's outlet line 1200mm DIA from Mutla High WDC to West Funaitees WDC	Residual Chlorine di-oxide	Residual Chlorine di-oxide	M	MC
S4	- 1 No. inlet 1200mm DIA from Doha (P10) to Mutla High WDC -1No. outlet 1200mm DIA from	Residual Chlorine	Residual Chlorine di-oxide		

	Mutla High WDC to Jahra -1No. Outlet 1000mm DIA for Mutla High WDC to Mutla Low and Abdaly.	di-oxide		M	MC

Notes:-

1- Each sample point shall be provided manual sampling facilities local to the sample point and each sample shall be conveyed to the lab.

2- Each sample point shall be provided with duty/standby pumps manual/automatic operation based on the low pressure and low flow. One pair of pumps (1 Duty /1 Standby) serving all the pipelines together each pipe line served by a pair of pumps.

3- Location of sample pumps shall be in the chamber or in the sample pump room.

4- Refer tender drawings.

Key: FR ClO_2 Free residual Chlorine- Di oxide.

M – Monitoring, C – Feedback dosing control.

5- All chlorine di-oxide solution lines, water supplying & sampling pipe works from chlorine di-oxide plant to chambers (water take off, injection,ClO_2SamplingChambers) should be in R.C. duct with proper supports.

6- Indications for all (Chemical injection, Dilution water, sampling, chambers), in/out of Pipelines shall be with arrow indication &identifications with colors codes. The colors shall be approved subject to the engineer.

7- Chlorine di-oxide analyzers should be located in analyzer's room.

(3.5.)ClO_2 Solution Transfer & Injection Tapping Points

At all injection points Chlorine di-oxide shall be dosed into main pipes using injection diffusers of with draw able type.

- Each point of application for Chlorine di oxide solution should be served by (duty / standby) dosing system complete with isolating valves & fittings, feeding ClO_2 solution injection points. Each injection point should be provided with four injection tubes manifolded together in a plane perpendicular to direction of flow in main pipe. As shown on tender drawings.
- Required complete pipe works for ClO_2 solution pipe lines from ClO_2 generation / dosing unit up to injection points (in ClO_2 injection chambers) via. R.C. trenches as shown on tender drawings.
- At each injection tapping point of outlet / pipe lines of reservoirs S.S.316L Isolating valve (ball type) should be installed, each injection line should have non-return valve at up-stream of isolating valve for each inlet & outlet of reservoirs as shown on drawings.
- Required complete pipe-works for ClO_2 solution transfer and injection system.

(3.6.)In /Out and Identifications of System Pipe-Works.

In/Out arrows, & identifications water lines, ClO_2 solution lines, sampling lines & reagents in side container and outside in R.C. trenches should be provided on all locations for whole system as per tender specifications.

1. Sign & identification for all equipments related ClO_2 system, pipe-works, electrical/ control, mechanical, chemical equipments should be provided, pipe-work in/out arrow signs as per engineer approval.
2. Sign/ identification for buildings individual sign for each building and related equipment rooms to be provided as per engineer approval.
3. R.C. trenches route identifications sign each 100mtr distance.
4. Sampling injection/ water take-off R.C chamber sign/ identification to be provided as per engineer approval.

(3.7.)Civil Works Related Whole System.

All kind of civil works relating Chlorine di-oxide plant (building) R.C (Rein Forcement concrete) foundations, basement, for storage tanks, water tanks all pumps, R.C. trenches with removable G.I steel covers for ClO_2 injection, sampling, FW lines are included & to be completed for whole system in all respect.

Construction of shed/ room, foundation and flooring etc. for the ClO_2 generator system & the foundation materials like grouting mix, foundation bolts & packing shims etc., are in bidder's scope. The bidder shall provide the equipment layout drawing along with bid. Detailed construction drawing with foundation requirement like load details, foundation pockets etc., for all the skids, equipment, tanks, flooring requirements, trenches for pipe routing, cable routing & drains etc. shall be furnished as per tender drawings.

Any special requirement like handling arrangement, floor / trench protection etc. shall also be indicated in the drawings. All the plant drains & trenches are to be connected in a common trench after sufficient dilution and terminated near Plant boundary. The approximate area & location are indicated in the enclosed lay out drawing. Bidder to accommodate the ClO2 system with in the stipulated area only as indicated in the typical layout drawing attached along with this specification.

R.C. trenches with removable steel covers details are shown on tender drawings, works include excavation, casting and construction of R.C. trenches & basement / foundations. R.C. trenches should be completed between ClO2 generating / dosing unit analyzer / sample room up to Tie-in points to these lines – in chamber as shown on drawings.

Any R.C manholes, R.C. trenches sleeves, system pipelines sleeves and civil works, electrical / control work related for installation of ClO_2 complete system for putting-in operation are included in scope of work as mention in the tender specification.

(3.8.)Raw Chemical Materials Quantities Required.

(a) Sodium chlorite 25% food grade.
(b) Hydrochloric Acid 32% food grade.

For Two years (24 months) operation period of ClO_2 generation /dosing system quantities of sodium chlorite 25% & Hydrochloric acid 32% are required for maximum dosage rate (0.8

mg/l) of ClO_2 at maximum water flow rates in total Nos. of main inlet & outlets of reservoirs as mentioned in specification to be supplied by contractor. (Included in tender).

(3.9.)Raw Chemical ($NaClO_2$ & HCl) Drainage Tanks &Transfer Pumps:

a) 2 Nos. of GRP chemical, resistant to (25% $NaClO_2$ &32%HCl) for each chemical of capacity 2000 Gal, each complete with inlet/outlet, vent & pipe-work to be provided inside R.C chambers (as mentioned in civil scope of works tender specification).

   - Ventilation fans (2Nos) complete with electrical work, power supply to be provided in side chamber
   - Lighting to be provided in side chamber (Min Dual 4Nos. fluorescent light)

b) 4 Nos. (2 duty /2standby) of chemical ($NaClO_2$& HCl) transfer pumps complete with power supply, pipe-work, LCP & related works should be provided. Each pump will operate according to float-system Low-Low/High-High level signals (Stop/Start) on automatic basis and respond Alarm/Annunciation on LCP/MIMIC/DAC.

(4.0.)ClO_2 Neutralization &Drainage Tanks:

- 2Nos. of GRP tanks chemical resistant to ClO_2 solution 2g/L conc. capacity 2000Gal (one for ClO_2 solution & one for waste water) to be provided complete with pipe work and drain of waste water to be connected to sewage system. These tanks should be installed in dedicated R.C manholes (Civil scope of work as mentioned in tender specifications) complete lighting & ventilation fan & electrical work.
- 2Nos. of transfer pumps (one for each tank) complete with civil, electrical & related accessories.

(4.1.)Instrumentation and Control (I&C)

- The plant to be designed to operate in fully automatic mode and for this purpose the following main control loops and interlocks will be provided.
- The control logic will be by 2 PLC (duty / hot stand by) for controlling the system for individual LCP of each group of water streams as mentioned in tender documents.
- The monitoring of the system operation will be from the LCP via touch screen graphic mimic showing the status & control of main equipments.
- LCP will do also supervision for storage tanks loading operations.
- 26Nos. ClO_2 residual analyzer (Measuring Assembly) / transmitter should be provided, the ClO_2 signal should display on LCP /PLC in skid & same ClO_2 residual signal should be transferred to LCP / MIMIC & DAC System.
- ClO_2 residual analyzer / transmitter having measuring range 0 – 2 mg/l
- Signal exchanged from LCP to DCS are the following:
- System not operating.

- System running

System Running Status include Monitoring / Control of

- Water filling pumps: (Duty / stand by): Run / Stop /O/T
- Dilution water tanks: (Duty / standby) tanks level , tank in use
- Water feeding pumps to reaction chamber: (Duty /standby), Run /Stop/ O/T\

Reagent Loading Pump Status.

- Pumps: Duty / stand by , Run / Stop /O/T

($NaClO_2$& HCl) Reagent Tanks.

- Sodium chlorite solution tank: Level indication Low / High
- Hydrochloric Acid Tank : Level Indication Low / high
- Control of filling tanks relating to low / high level of tanks.

Reagents Dosing Pumps

- Pumps: duty / standby, Run / Stop / O/T.
- Pump dosage rate: in Kg/hr. (monitoring on LCP, HMI & MIMIC/DAC)

ClO_2Reaction Chambers

- Reaction chambers: duty / standby status
- Reaction chambers ClO2 generating Capacity in Kg/hr (Monitoring)

ClO_2 Solution Dosing Section

- ClO_2 dosing pumps. Duty / standby for each dosing line Run/ Stop /O/T.
- ClO_2 dosage rate of pump in Kg/hr (Monitoring)
- (Compound loop control) of ClO_2 dosage as function of flow water signal & residual chlorine di-oxide signal.
- Water flow rate indication for each main inlet & outlets of reservoirs monitoring in L/S.
- ClO_2 residual signal in ppm of ClO_2
- Set point Controller for ClO_2

Main operation from LCP (Local / Remote) from mimic Auto operation from PLC via (HMI) touch screen graphic mimic & DAC system.

- General fault
- Low level in the HCl storage tank (Auto shut off ClO_2 system)
- Low level in the Na ClO_2 storage tank (Auto shut off ClO_2 system)

- Reagents storage unloading pumps are managed only by local.
  The following interlocks have been considered:
- Hydrochloric acid tank high level causes the interlock of the relevant unloading pumps.
- Sodium Chlorite tank high level causes the interlock of the relevant unloading pumps.
- Hydrochloric acid tank low-low level causes the interlock of both reagent dosing skids.
- Sodium chlorite tank low-low level causes the interlock of both reagent dosing skids.

Each (duty / stand by) reaction chamber (generator) can work with any of the duty / standby reagent dosing skids; a suitable two-position selector "Reaction chamber 1 / Reaction chamber 2" will be available at LCP for the selection of the reaction chamber.
A suitable two-position selector "Reagent skid 1 / Reagent skid 2" will be available at LCP for the selection of the skid on duty and of the skid on standby.

The two reagents dosing skids have two operation modes:

- Manual : operators can decide the flow rate of dosing.
- Automatic : pump regulation depends on the water flow rates (or/and residual ClO_2 by the analyzer) to the reaction chambers.

The following interlocks have been considered:

- Hydrochloric acid tank low-low level causes the interlock of both reagent dosing skids.
- Sodium chlorite tank low-low level causes the interlock of both reagent dosing skids.
- Low-low level in the dilution water tank causes the trip of the reagents skids and of the ClO_2 dosing pumps.
- If skid1 / (Skid2) are on duty, every related pump electric motor failure trips the reagent Skid 1/ (Skid2).

ClO_2 Dosing to the each inlet/outlet line of reservoirs as mentioned in specification / tender drawing

Each of the chlorine dioxide dosing pumps has two operating mode:

- Manual: operators can decide the flow rate of each pump.
- Automatic: pump regulation depends on the flow rate in each inlet/outlet line of reservoir Flow fraction controller) and on the ClO_2 residual concentrations on the header (feedback loop for adjusting ratio factor).

A selector for each couple of pumps has been foreseen to select the pump on duty and on standby. In automatic operation mode the operator sets the ClO_2 residual concentration and the dosing pump flow rate is automatically modulated in function of the water flow rate (Flow-fraction control) with the correction done by the residual chlorine dioxide controller in the range +/-20%.

The following interlock has been considered:

- Low-low level in the dilution water tank causes the trip of all the ClO_2 dosing pumps.

- For each chlorine dioxide dosing pump that is on duty, the electric motor failure causes the trip.

(4.2.)ClO_2 analyzers Specification (Latest Model):

Measurement Principle	: Electronic Type Sensor
Protection Class	: IP65.
Overall accuracy	: ± max. 0.5 % of measured value ±4 digits.
Repeatability	: - max. 0.2 % of measuring range
Output	: Two wires, 4-20 mA, isolated.
Temperature compensation	: automatic, built-in.
Local indication	: digital, LCD indicator.
Mounting	: local on 2" pipe, mounting kit (bracket, clamp, nuts etc.) to be Supplied or flat vertical surface such as wall,panel,stand etc.
Sensor	: flow through with flow powered cleaner
Assembly body	: PMMA, Mounting parts: PVC, stainless steel 1.4571 (AISI 316 Ti), EPDM.
Measuring electrolyte	: buffer solution.
Pre-amplifier	: built-in.
Power Supply	: 110V AC ± 10% 50Hz ± 1%
Calibration	: semi-automatic using pre-configured buffer tables.

Span and Zero adjustment required.

ClO_2 analyser shall be installed in such a manner that wetted parts are protected from oily sludge & other impurities present in the water. Automatic timer actuated cleaning / purging system should be provided to enhance the life of electrode.

- 26 Nos. of Chlorine dioxide residual analyzer / transmitter (ClO_2 measuring Assembly) should be provided, installed in analyzer room / chemical building complete Pipe-work.
- ClO_2 residual monitors / indicators complete with signal cables / accessories to be provided / installed on treatment monitor LCP (MIMIC) panel.
- ClO_2 residual signals to be used for man/auto control of ClO_2 dosing system
- ClO_2 residual signal from each inlet & outlet of reservoirs lines as per tender's specification injection points should be exchanged from LCP to DAC System.
- Water flow rates signals from each inlet & outlet line of reservoirs should be provided from flow transmitter to LCP/DCS for monitoring / control of ClO_2 dosage rates, includes whole scope of works (Signal cabling, Control cabling, interfacing with field equipment's, MIMIC & control equipment) for complete Man /Auto operation of system in all respect.

(4.3.)Chlorine Di Oxide Leakage Detection

Chlorine dioxide leak detectors shall be supplied and installed in chlorine di oxide generator room, ClO_2 pump room and in main pipelines ClO_2 injection chambers as indicated on the PID of the ClO_2 system.

ClO_2 leak detector shall provide 4-20mA output proportional to ClO_2 in air concentration. The detectors shall also incorporate high and extra high audible and visual alarms that shall be activated automatically when the ClO_2 in air concentration exceeds adjustable pre-set levels. Local alarm panels of the "traffic light" type with green for clear, amber for low level leak and flashing red for high level leak shall be provided as detailed in the water treatment specification. The ClO_2 leak detectors shall be linked with exhaust fan to run auto mode based on the leak set point.

Chlorine dioxide leak detectors complete with monitoring panels and leak sensors shall be provided as follows:

a) ClO_2 generator room: Four detectors each with Four sensors
b) ClO_2 Pump room: Two detectors with Two sensors
c) 6Nos of ClO_2 injection chamber as shown on tender drawing = (one detector with one sensor in each chamber)
d) ClO_2 leak detection system in injection chambers to be provided complete with ventilation fan lighting, Ladder, Walk-way & safety cage.

Note: Item a, b, c& d, shall be linked with exhaust fan. The exhaust fan shall run in auto mode based on the leak alarm set point and shall have provision to operate in manual mode.

The monitoring panels for detectors in the ClO_2 building shall be located in the control room annunciate as specified at each entrance to the respective area.

All the ClO_2 in air concentration measurements and alarms shall be monitored by the ClO_2 plant Local Control Panel in the control, at the workstation.

Leak alarm settings shall be:

- Low level 1 ml/m^3
- High Level 3 ml/m^3

Leak alarm /indication should initiate on LCP/ MIMIC alarm initiator/DAC system
e) Interlock to be provided for control & interlock between ventilation & A/c should be provided. In case of ClO_2 leak alarm ventilation system will initiate and A/c system shut off automatically in the ClO_2 leakage respective Room/ Area.

(4.4.)<u>Sump Pump In Chambers:</u>

- 3set (Duty/ standby) sump pump in injection, pre sampling & post sampling chamber, complete with float system, flood-alarm, man/auto operation from LCP, HMI/ MIMIC/OWS/DAC should be provided with related pipe-work, sump-pit, power-supply-electrical & control work complete in all respect.
- Two set (duty/standby) sump-pumps (one in ClO_2 generator room & one in pump room) in complete scope of work as mentioned above to be provided in R.C trench-sump-pit of chlorine dioxide& pump rooms of chemical building.

(4.5.)<u>Safety Equipment For ClO_2System :</u>

The safety equipment's for ClO_2 system to be utilized by operator

- Safety kit complete as recommended by manufacturer

& chlorine institute (U.S.A) 1No

- Air-breathing apparatus 1No
- Safety goggles 50Nos
- Gas-mask (with ClO_2 canister) complete 20Nos
- Safety face protectors 20Nos
- Safety gloves 50set
- Safety signs-boards in different location for ClO_2 plant as per layout of building to approval of engineer

Raw Chemical Storage Building& ClO_2 Generator Chemical Building

- Fire - fighting as mentioned in tender specification to be provided
- Ventilation system link with ClO_2 leak to be provided as per tender specification
- Air conditioning system as tender specification
- Safety shower, eye-wash-complete with pipe-work, drain pipe work, water supply-work to provided in ClO_2 generator building (4Nos x 100%) and 4Nos x 100% in raw chemical building as identified location on building lay-out to engineer approval.
- Safety sign board in ClO_2generatorstorage building, Raw chemical, Storage tank area & ClO_2 injection chamber should be provided at locations as per approval of engineer (safety signs sample to submitted for approval)

(4.6.)Electrical equipments.

- Contractor should calculate & submit total power (load) required for specified ClO_2 generating / dosing system.

- Contractor should provide electrical equipments (Main switches & power cables, MCC Isolators etc.) including main & individual power cables with complete installed / tested from main power supply (Feeder) to all (MCC for electrical equipments used in ClO_2 generation / dosing system.

- If any other items required to complete installation , operation of ClO_2 generating / dosing & chemical loading plant should be included in the bid (Break down this item should be provided)

(4.7.)General Requirements.

The manufacturer should be specialized / certified body in the field for designing, installing, testing/ commissioning & maintenance on site generating / dosing ClO_2 plant. Manufacturer should submit his past/present experiences with details documents for such projects completed worldwide. The specified / certified body should be capable of handling such projects, suitable for disinfection of minimum Fresh water (FW) production 50 MGD.(Worldwide projects completed details should be submitted for qualification supporting bid/offer.

(4.8.)Guarantee

All supplied and installed materials, equipments & other accessories of the ClO_2 generation /dosing plant should be guaranteed for a period of Twenty four (24) months starting from date of handing-over the required plant. Guarantee shall be comprehensive and against any defect arising from defective design materials / equipments or work manship.

(4.9.)Performance Guarantee

The bidder shall guarantee all equipment for workmanship, materials and satisfactory performance. The guarantee for performance will cover individual items and systems including electrical for their ratings / outputs as well as for the integrated operation of equipment and its auxiliaries as a whole. On completion of satisfactory commissioning, the supplier shall conduct performance / acceptance tests on the equipment and system as a whole for demonstrating the guaranteed performance parameters specified. All instruments, gauges installed for the normal operation of equipment shall be made use of during the acceptance test as far as possible. If additional instruments are required for the tests, these shall be brought by contractor at free of cost and shall be taken back after performance test. The guarantee tests shall cover the following but not be limited to the rated parameters for smooth operation of complete ClO_2 system:

a. ClO_2 generator capacity & dosage requirements as mentioned in tender specification
b. Power consumption for continuous operating equipment
c. Vibration and noise level of rotating equipment

(5.0.)Operation & Maintenance

The contractor should operate & maintain the required plant complete with spare parts needed during maintenance for a period of Twenty four (24) months starting from the date of handing-over the plant to client.

- Operation of ClO_2 plant will be 24 hrs daily on shift basis (Mor, After, Night) each shift should have 2 operators for period of two years (twenty four) 24 months as mentioned above.
- Operator Qualification as follows: Education Should have secondary school certificate (SSC) with technical diploma in Mech./chemical.
- Experience: Minimum 5 (five) years experience in operation & maintenance of chlorine di-oxide generating & dosing plant.

(5.1.)Spares

Spares for the required ClO_2 system as mentioned below.

(a) Spare equipments should be provided

- (32% HCl & 25%$NaClO_2$) Reagent loading pump. 2 No.
- (32% HCl) Reagent dosing pump. 2 No.
- (25% $NaClO_2$ Reagent dosing pump 2 No.
- "Under water or Under Vacuum type" ClO_2 Generator complete 2 No.
- ClO_2 solution dosing pump. 6 No.

- ClO_2 residual analyzer. 6 No.
- Complete ClO_2 generating skid capacity 20kg/hr 1 No.
- Dilution water Pump complete 2 No.
- The recommended spare for control equipment and LCP (break down for this item to be provided for MEW approval)

(b) Spares recommended by manufacturer for the maintenance of ClO_2 system equipments for a period of 2- year should be provided (Spares list should be submitted for approval to MEW)

(5.2.)Technical Training after Commissioning the Plant

MEW staff should be trained for operation & Maintenance of the required ClO_2 producing / dosing plant. Total 10 No. of operators and 8 No. of maintenance personal are to be trained at site in different basis. The engineer can release maximum 8 personal at time each batch to be trained for minimum of 14 days on the system supplied. Details of training course schedule, dates should be proposed by the system specialist contractor and to be reviewed by the owner.

(5.3.) Testing & Commissioning

After installations are completed the contractor shall conduct acceptance test according O&M procedures, to conform the compliance of the system with specification requirements. The contractor shall submit a list of acceptance test procedures to perform for engineer's approvals. Contractor shall provide the qualified man power and calibrated test equipments to carry out the acceptance tests.

(5.4.) Reliability Test Period

After the main part of work has passed the engineer's inspection and test of completion and has been put into operation. The reliability period of one month should be completed after commissioning of the system.

(5.5.) Site Survey

Tenderer should visit the site in order study / estimate the required ClO_2 producing / dosing project. Tenderer / contractor should submit preliminary report including detailed layout, PID's and design drawings of system for approval to start final report. Any amendments in the report should be taken into consideration in final report. Contractor should get approval on final report from the concerned authorized section to start the construction drawings / documents of the required project.

(5.6.) Plant (Instruction Operation / Maintenance Manuals)

- 6 sets complete operation & maintenance instruction manuals for whole ClO_2 project (installed) should be submitted with their soft copy.

- 6 Sets complete of Shop-Drawings / As-built drawings of the said system should be submitted (Hard and soft copy).
- 6 sets of System Lay-out & PID's should be submitted.
- Supplier has to arrange presentation on ClO_2 required system for MEW to discuss /clarify the points before approval of the offer.

(5.7.)DOCUMENTATION:

(5.7.1)GENERAL:

The documentation during bid and post order stage shall meet the following requirements.

1. All documents and drawing shall be submitted in English
2. Hard copies of all documents and drawings during bid stage to be submitted induplicate.
3. Hard copies of all documents for approval shall be submitted in triplicate.
4. Hard copies of all final documents, drawings, Erection and O& M manual etc., shall be submitted in bound folder in 6 copies.
5. Soft copies of all final documents in MS word / MS office in the form of CD –1 set
6. Soft copies of all final calculations in MS excel/ MS office in the form of CD–1set
7. Soft copies of all final drawings in Auto Cad, latest version in the form of CD-1set

(5.7.2)DOCUMENTS During Preliminary Design Report:

The following drawings / documents are to be submitted during preliminary design report.

1. Technical write-up giving details of equipment operation, interlocks / control requirement.
2. Typical Quality Plan for major equipment (ClO_2 generator, pumps, tanks, dosing system, piping & valves etc.).
3. Process calculations.
4. Typical ClO_2 generator guarantee document.
5. Storage procedure before commissioning.
6. Datasheet for ClO_2 generator system
7. Preliminary P& I diagram
8. Preliminary Equipment layout drawing
9. Typical arrangement drawing & isometric drawing of skid with piping, valves, maintenance, walkway etc.,
10. Filled up data sheets as called in the specification – Annexures 1 to 3
11. Maintenance procedure
12. Utility requirements like instrument air, service air and service water for maintenance of the system.
13. Pump performance curves with marked duty point.
14. Sub vendor list for mechanical, electrical and C&I items.
15. Preliminary civil requirements.
16. PLC I/O list.

17. Tentative quantity of Power, Control and Screened cables to be supplied for the UF System by the Purchaser.

(5.7.3)DOCUMENTS AFTER ORDER

(5.7.3)A.Phase-I (for approval):

1. Technical Write-up and design basis
2. P&ID diagram including pipe sizes & terminal points.
3. Equipment layout showing building details, headroom, equipment.
4. Sizing, process calculations for equipment
5. Filled up datasheets for approval as per Annexures 1 to 4
6. ClO_2 generator system "Control Description" write-up including operation, controls, interlocks, protection, annunciation etc.
7. Activity chart / Bar Chart and schedules for drawing submission, manufacturing, erection and commissioning.
8. Quality Plan and field quality checks, stage inspection etc. (for ClO_2 generator, pumps, tanks, dosing system, piping & valves etc.,).
9. Guarantee Document.
10. Equipment Datasheet.
11. Performance curves for pumps & motors
    a. Flow Vs Head
    b. Flow Vs efficiency
    c. Flow Vs Power
    d. Flow Vs NPSH
12. Instrument schedule.
13. Typical arrangement drawing & isometric drawing of skid with piping, valves, headers arrangement including space for maintenance, walkway etc.,
14. Write-up about maintenance of equipment
15. PLC I/O list.

(5.7.3)B. Phase-II(for approval):

1. Storage procedure before commissioning
2. Piping and Valves schedule
4. Foundation Design drawings indicating foundation design, load data, anchor bolt location, pocket details, floor & trenches etc.
5. General arrangement drawings for all the equipment showing dimensions and details of materials.
6. As-built manufacturing drawing of the skid frame and equipment, assemblyincluding piping & valve system arrangements with Bill of material (BOM)
7. Isometric drawing of pipe segments.
8. Cross sectional drawing of pump etc. with BOM

(5.7.3)C.Phase-III (for information-before dispatch):

1. Erection manual indicating
    a. Erection/installation instructions of equipment.
    b. Log sheet containing stage check parameters & clearance
    c. Log sheets for alignment check of pump & motor
    d. Field quality checks
2. Performance Test procedure
3. All the documents called in Electrical specification.
4. Shipping list for MEW approval

(5.7.3)D.Phase-IV (for review):

1. Pump performance test reports
2. Pump performance guarantee certificates
3. Operation and maintenance manual indicating, Operating procedure for start-up, normal operation, shut down and emergency shutdown. (O & M manual shall be supplied with 6 sets of hard copies and one set in soft form in CD.
4. Maintenance instruction & assembly
5. Lubrication chart.
6. Electrical equipment layout, Cable trench layout, cable routing, cable schedules and cable termination details.
7. ClO_2 generator system Logic diagram & Sequential Flow Chart (SFC) for PLC/Redundant PLC.
8. Cable interconnection diagram for cables up to junction box & cable schedule.
9. Test Certificates for all the supplied instruments.
10. List of alarm, interlock & trip set points
11. Installation drawings for instruments
12. Wiring drawings & GA drawings for Local Panels, junction boxes.
13. As built drawings.
14. All other details called in Electrical specification.

(5.8.)ATTACHMENTS

The following drawings enclosed are a part of the specification:

1. PID for ClO_2 system
2. ClO_2 system equipment layout
3. Erection, commissioning, PG test & handing over as per tender specification
4. E, C &I as per tender specification
5. Electrical motor as per tender specification
6. Vendor list (Annexure-A)
7. Painting specification (Annexure-B)

Annexure-1

DATA SHEET

I)ClO_2 GENERATOR

Sl.No.	Description	Unit	Capacity
		Kg/hr	

II)CHEMICAL CONSUMPTION

Sl.No.	Description	Unit	Quantity
1	HCl consumption	Kg/hr	
2	$NaClO_2$ consumption	Kg/hr	

Annexure-A

I) Vendor List for ClO_2 Equipment Mechanical Instrumentation Items:

List of recommended manufacture (ClO_2/ Generator)

- CaffaroTaly
- ISIA S.r.l.Italy
- Wallace &Tieman U.K
- Seven trend U.K
- Culigan USA
- Prominenet Germany
- Capital Control U.K
- Grundfos-Aldos Germany

List of recommended manufacture (GRP Tanks)

- M/S Al Watani Kuwait
- ISIA Al Yusifi Kuwait

List of recommended manufacture (Control Pannel, LCPS and MCC etc.)

- Rosemount USA
- ABB Germany
- M/S Siemens Germany
- G.E France U.K
- Honeywell International USA
- Mitsubishi Heavy Industries Japan
- yokogowa Japan
- Foxboro USA
- Ebomac Kuwait
- Salem Al-Nisif Electrical Co. Kuwait

- Al-Ahalia Kuwait

List of recommended manufacture (Centrifugal Pump)

- M/S Grandfos pump
- M/S Worthington Simpson (Flow serve pump)UK
- M/S Ingesrol Pump U.K
- M/S Ebara Pump Japan
- M/S Troshima Pump Japan

List of recommended manufacture (Metering Pump)

- M/S Carshin dosing pump U.K
- M/S Wallace / Tieman U.K
- Rekos pump U.K
- Prominent Metering Germany
- Aldos Germany
- M/S Fulsa-Feeder Germany

List of recommended manufacture (Pipe & Fittings PVC))

- M/S Adssani piping co. Kuwait
- M/S George fisher U.K

List of recommended manufacture (Analyzer & Instrument)

- M/S ABB Germany
- M/S Wallace/Tieman U.K
- M/S Siemen (Seventrent)
- ITI Instrumentaion USA
- Capital Control U.K
- Endress # Hauser(Germany)

Note: Vendor List for Instrumentation items is provided in the specification. Vendor shall consider the instrument supplier as identified in the Vendor List. Vendor list provided in the package is for the Make only, and not for any specific Model. For any instrumentation item, the offered model for the same must meet the specification and proven track record (PTR) requirement. For all special Instruments and systems like On-off valves, field instruments, Analysers, PLC system, EIL(PMC) approved vendor List shall be followed. This is applicable for skid mounted instruments as well.

Annexure-2

Power Load of ClO_2 Equipments

Sl. No	Equipment Description	Qty		Pump efficiency	Drive Rating KW	Conn load.Load KW	Power consumption KW	Voltage, Phase
		W	SB					
A	FOR CONTINUOUS OPERATING							

	EQPT.							
1								
2								
3								
	Sub total of A							
B	FOR INTERMITTENT OPERATING EQPTS.							
1								
2								
3								
	Grand Total							

Note: W – Working SB – Standby

Annexure- 3

EQUIPMENT DATA SHEET FOR CHLORINE DIOXIDE SYSTEM

01).PUMPS : ClO_2 Diln Pump Unloading Pumps

I.TECHNICAL PARAMETERS **Dilution** **HCl** **$NaClO_2$**

a. Make :
b. Model :
c. Fluid details
- Medium handled :
- PH range :
- TDS/Chloride range ppm :
- Temperature range deg.C :

d. Rated flow / Head (at Disch) m^3/hr &mwc :
e. Min. & Max continuous flo m^3/hr :
f. Corresponding discharge Head mwc :
g. Shut-off head mwc :
h. NPSH required (minimum) mwc :

i. Design Pressure kg/cm^2 :
j. Hydraulic test pressure kg/cm^2 :
k. Pump efficiency at duty point% :
l. BKW reqd. for pump at duty point kw :
m. Maximum KW required kw :
n. Recommended Motor KW kw :
o. Rated speed rpm :
p. Noise level at duty range dBA :
q. Vibration level peak to peak mm :
r. Balancing quality :

II.CONSTRUCTION DETAILS

a. Orientation Horizontal / Vertical :
b. Suction / Discharge nozzle
- Size mm :
- Rating psi :
- Orientation :
- Material :

c. Material of Construction / Make
- Pump Casing :
- Impeller :
- Shaft :
- Shaft Sleeve :
- Fasteners :
- Others if any :

d. No. of stages :
e. Impeller type :
f. Impeller diameter Trimmed / Untrimmed :
g. Bearings
- Type :
- Make :
- Lubrication oil spec. :

h. Performance Curve ref Nos. :
i. Pump dimension L x W x H :
j. Pump Weight :

III.COUPLING

a. Type :
b. Make, Model No. :
c. Weight kg :

IV.BASE FRAME AND ACCESSORIES

a. Material :
b. Dimension detail mm :
c. Weight kg :
d. Foundation Bolt - Size & Qty mm & Nos. :
- MOC :

V.GENERAL

a. Shipping package dimension mm :
b. Total Assembly / Shipment weigh kg :
c. List of Special tools :
d. Accessories details :
e. G.A. Drawing No. :

02).BULK STORAGE TANKS HCl $NaClO_2$

a. Capacity m^3 :
b. Type Horizontal :
c. Size Dia. & height mm :
d. Tank thick, bottom, circumference :
Top cover :
e. Material of construction :
- Tank :
- Tank cover :
- Drain valve :
- Level indicator :
- Interconnecting valves &piping :
- Wetted parts :
- Non wetted parts :
f. Type of resin used for FRP tank &Cover :
Inner / outer
g. Type & make of level transmitter :
h. Level Indicator make & details :
i. Colour of the tank :
j. Nozzle size of inlet, outlet, drain, overflow:
k. Outlet & drain valve size & type :
l. Empty Weight :

03).CHEMICAL DOSING SYSTEM (Acid, $NaClO_2$)

I. Dosing Pump:

a. **Name of chemical dosing system : HCl $NaClO_2$**
b. Make & Model No :
c. Type :
d. Flow
- Design Min / Max lph :
- Rated Min / Max lph :

e. Discharge Pres.
- Design Max kg/cm2 (g):
- Rated Max kg/cm2 (g):

f. Suction lift mwc:
g. Stroke length Min / Max mm:
h. Speed Min / Max rpm:
i. Stroke adjustment Min / Max %:

j. Flow Accuracy on design capacity %:
l. Repeatability %:
m. Power supply details V / Ph / Hz:
- Variation V / Ph / Hz %:
- Power consumption watts:

n. Material of construction
- Dosing Head :
- Fittings :
- Valve balls :
- Spring in injection head :
- Diaphragm :
- Tubing :
- Mounting Fasteners :
- Other wetted parts :

o. Normal operating life at design capacity :
- Diaphragm hrs :
- Ceramic balls hrs :

p. Pump overall size L, W,H mm:
q. Pump weight kg:
r. Tube size :
- Pressure rating at 20 deg.C kg/cm^2(g):
- Suction Inches : ID x OD
- Discharge Inches : ID x OD

II. Accessories for Pump:

a. Anti-syphon / non-return valve :
b. Air Release Valve :
c. Pressure relief valve :
d. Pump mounting fasteners :

05.)CHLORINE DIOXIDE GENERATOR SYSTEM:

a. Separate datasheet & process calculation for ClO_2 generator system shall be provided by bidder along with the technical offer.

Annexure – 4

VALVE SCHEDULE – DATA SHEET TO BE FILLED BY THE BIDDER

Sl. No	Service	Valve Type	Size	BODY	Disc / Ball / Diaphragm	Stem / Shaft	Valve seat/ Seat ring	Hinge Pin	Valve Ends
1	Manual valves								
2	Pneumatic Valves								
3	Check Valves								

Annexure-5

RECOMMENDED SPARES FOR 2 YEARS O&M WITH PRICE

Sl. No	Description of the equipment	Description of spares	Quantity	Price

Annexure-6

TECHNICAL DEVIATIONS

Sl. No	Section no.	Clause No.	Page / No.	Specification	Statement of Deviations/variations	Reason for Deviation

(5.9.) LAB FURNITURE:

(5.9.).I. Specification for Laboratory Fume Hoods

PART 1 GENERAL

(1.1) General Requirements :

A. This Specification identifies the minimum material and construction standards that are required to deliver a quality installation of laboratory fume hoods. Fume hoods shall be supplied in accordance with the requirements of this Specification. The fume hoods identified in this Specification shall include the components as identified on the Drawings and that are necessary for the complete installation.

(1.2.) SECTION INCLUDES

A. Manufacturer
B. Fume Hood Materials & Construction

(1.3.) DELIVERY, STORAGE AND HANDLING

A. Schedule delivery of fume hoods and equipment so that spaces are sufficiently complete to allow for installation immediately following delivery.
B. Protect finished surfaces from soiling or damage during handling and installation. Protect all work surfaces from damage throughout construction period. Mark in large lettering "NO STANDING" to not allow standing on work surfaces during the construction period.

(1.4.) SUBMITTALS

A. Submit manufacturer's data and Installation and Operation Instructions Manuals for each type of fume hood. Provide data indicating the compliance with EN 14175 standard.
B. Submit shop drawings for fume hoods showing plans, sections, elevations, service run and location.
C. Samples:
1. Submit 100 mm x 100 mm product sample of each type of work surface.
2. Submit 60 mm x 100 mm samples of interior fume hood liner material and exterior fume hood material.

(1.5.) DESIGN & PERFORMANCE REQUIREMENTS

A. Fume hood shall be designed to function as an enclosed ventilated workspace. Its purpose is to protect the operator from harmful fumes and vapors generated within the enclosure. It shall perform these functions by capturing, containing and exhausting the fumes safely and efficiently out the enclosure and by utilizing the sliding safety glass sash as a shield for the operator's face and body.

B. The design of the fume hood enclosure shall be an aerodynamically efficient fume exhaust system, minimizing turbulence within the chamber and the air volumes being exhausted from the laboratory.

C. Fume hoods types :

(i) Open Bypass/ Constant Air Volume:

The fume hood shall be of the bypass type. The fume hood design shall allow for automatic air bypass above the sash opening. The bypass shall limit air velocity from increasing as the sash is lowered and provide for a constant volume of air through the hood regardless of sash position.

D. Manufacturer of Fume hoods shall have the capacity within his own plant facility of performing fume hood tests based on the latest EN 14175 specifications.

(1.6.) REFERENCES

Manufacturer should have a proven capacity in similar projects and should present references in at least 3 projects of similar nature and size.

PART 2 PRODUCTS

(2.1.) MANUFACTURER

A. Fume hoods shall be the product of one manufacturer dully certified by international standards in the production of such equipments.

B. The manufacturer shall provide a one year warranty against defects in material or workmanship from date of installation.

(2.2.) FUME HOOD MATERIALS & CONSTRUCTION

A. Fume hood superstructure: Fume hood models shall be double wall construction consisting of an outer shell of steel and an inner hood liner. Exterior side panels, top front panel and vertical front posts are made of epoxy-coated cold-rolled sheet steel 16 gauge 1,5 mm. All panels shall be easily removable for maintenance.

B. Fume Hood Dimensions:

Outer width	1800 mm	1500 mm	1200 mm
Outer depth	960 mm	960 mm	960 mm
Outer height	2500 mm	2500 mm	2500 mm
Inner width	1680 mm	1380 mm	1080 mm
Inner depth	794 mm	794 mm	794 mm
Inner height (working height)	1200 mm	1200 mm	1200

C. Fume Hood Exhaust Collar: Fume hood exhaust collar shall be located at the top of the hood and shall be fabricated of polypropylene. Round in configuration of 250 mm ID.

D. Fume Hood Liner :

1. Zinc protected cold rolled steel, 1, 5 mm thick with high chemical and fire resistance (M0 material) coated with polymerised low reticulation resin.

a. Chemical Resistance Test: Wash and dry surface with mild soap and dry prior to testing. Apply 10 drops (approximately 0.5 cc) of each reagent identified on the clean test panels at room temperature for 30 minutes according to UL 1805 standard. Flush away chemicals with cold water and examine surface under 100 foot candles of illumination.

b. Evaluation ratings: Change in surface finish and function shall be described by the following rating:

1. Fully Satisfactory: No detectable change in surface material.
2. Slight finish deterioration: Slightly detectable change in color or gloss, but no change to the function or life of the work surface material.
3. Bleaching: A clearly discernable change in color or gloss, but no significant impairment of working surface function or life.
4. Unsatisfactory: Objectionable change in appearance due to surface discoloration or etch, possibly resulting in deterioration of function over an extended period of time.

c.Test results :

REAGENT	LINER & RATING Polymerised low reticulation resin
Sulphuric Acid (50%) Sulphuric Acid (98%) *Nitric Acid (65%)* Acetic Acid	(1) (2) (1) (1)
Sodium Hydroxide Potassium Permanganate	(1) (2)

REAGENT	LINER & RATING
	Polymerised low reticulation resin
Potassium Permanganate	(2)
Sodium Hydro chlorite Acetone	(1) (1)
Phenol	(2)
n-hexane Methyl Ethyl Ethyl Acetate	(1) (1) (1)
Fluorhydric Acid Chloroform	(2) (1)

E. Fume Hood constant airflow: A streamlined airfoil of polymerised low reticulation resin coated steel shall be located at the bottom of the sash hood opening. This foil shall provide an approximate nominal 25 mm open space between the foil and the top front edge of the work surface to provide a constant flow of air across the work surface. The airfoil shall be removable.

F. Fume Hood Baffles: *Three-piece* main baffles shall provide controlled air vectors into and through the fume hood and be fabricated of the same material as the liner. A fixed, permanently-open, horizontal slot of 25 mm located at 480 mm above the work surface shall be provided. Exhaust slots on the full perimeter of baffles. The baffle shall be removable for cleaning.

G. Fume Hood Lighting: A two-tube fluorescent light fixture of 220V shall be provided at the top of the hood. The replacement of the lamp shall be made from exterior working surface outside without disturbing the interior of the fume hood. The light fixtures shall be isolated from the hood interior by a metacrylate panel.800lux measure at the work surface.

I. Fume Hood Sash:

1. A vertical rising sash of 5 mm tempered safety glass shall be provided. Glass is mounted in vertical rising anodized aluminium. Frame coated with an aluminium polymerised low reticulation resin with Aluminium handle at the bottom. The sash shall be counter balanced using 2 stainless steel cables of 3 mm each. Sash shall lock in case 1 cable is broken. The access to the counter weight and cables is through the left side panel of the hood near the frontal part. A combination of horizontal sliding or vertical rising sash composed of one piece sash in the upper part of 5 mm and 2 horizontal sliding sashes in the lower part of 6 mm tempered safety glass made of anodized aluminium polymerised low reticulation resin protected. Sashes are placed in a vertical rising frame with a full aluminium epoxy coated handle at the bottom. The 2 lower glass panels shall slide in a polyvinyl chloride track.

2. Fume Hood Sash Stop: Fume Hoods shall be provided with a manual sash stop at 400 mm according to EN 14175 Standard

J. Fume Hood Services Fixtures: Fume Hoods shall be designed with vertical mounted service fixtures and shall comply with EN 14175 Standards. Vertically front double-wall posts shall be pre-punched to accept up to 10 plumbing fixtures per side. Fixtures shall be color coded for better identification. Posts shall be removable for accessibility to all services from the front of the hood. Taps used for current fluids should be full brass body covered with 11 polyamide.

J. Fume Hood Electrical Services: Electrical fixtures shall be mounted in the vertical front double-wall posts. Pre-wired 4 duplex electrical

outlets on each post (factory prepared for up to 6 duplex). Wiring shall terminate in a junction box located on top of the fume hood. All the service outlets should be easily accessible due to their location near the fume hood entrance and their controls should be on the outside above the vertical channels. The electrical sockets should be grounded by an isolated circuit breaker. Its location makes it easy to connect devices placed inside the fume hood. The electrical sockets should be located on the side channels and not below the work surface, thus avoiding the risk of short-circuiting due to accidental liquid spills. The protective level shall be IP55. The electrical sockets should be on the outside to avoid explosion hazards caused by touch sparks from the plugs.

K. Fume Hood Work Surfaces:

1. The work surface should be made of one piece dished vitrified Ceramic 35mm thick to contain spillage. With own drip cup glued to it, in one of the back corners to maximised the working level.

E. Fume Hood Monitor System:

1. Variable Air Volume (volume of air to be exhausted varies according to sash opening)

a. VAV System: Provide monitoring system that permits to know and control the operating status of the fume hood. Air volume exhausted shall be programmed to vary according to sash opening. Sensing devices respond to changes in the hood and operate a volume control device (damper) to maintain the face velocity within the desired range. Possibility to select a maximum of air volume exhaust wherever sash is positioned for security. The system shall provide audible and visual alarm if exhaust air volume falls below the pre-programmed stage set-points.

1. Monitor Panel: Located on vertical front post of the fume hood. Monitor shall have function keys of lighting on/off switch with pilot light and extraction fan on/off switch with pilot light, audible/visual alarm alerts of low face velocity, silence reset button, visual warning for excessive sash opening (500 mm), constant airflow 3 coloured LED graph of face velocity, internal temperature controller with audible/visual alarm (fire prevention), minimum airflow switch for night-time reduction, maximum airflow switch for emergency, port series for calibrating airflow set-points and global safety recommendation and alerts display with digital messages.

2. Processor Unit: Located on top of the fume hood. The processor shall be connected to a monitor panel, a damper located on the exhaust collar for air volume adjustments by opening and closing blades, a pressure gauge placed in the damper for pressure differential information, sash opening sensors, a thermostat for temperature control inside the hood and/or air velocity sensor.

3. Alarm signal: Visual (red LED) and audible alarm when low airflow. Visual (yellow LED) and audible alarm when high airflow. Visual and audible alarm when temperature inside the hood should be over 48ºC (over 60ºC fan stops)

4. Automatic sash stop at 400mm high according to EN 14175.

E. Fume Hood Instruction Label: Attached corrosion resistant instructions plate to the fume hood exterior

F. Fume Hood lower body

Select from the following:

1. "C" frame mounted :
   Casted anodized aluminium epoxy painted.

2. Standard Base Cabinet:

a. Base units under hoods shall be fabricated of cold rolled steel electrostatically zinc coated of 21 gauge (0.8 mm).
b. 18mm thick double wall door with 270º opening hinges. One internal adjustable shelf 22 mm thickness.
c. Shall incorporate a toebase of 120mm to support the unit.
d. Dimensions:

Fume hood size	Base unit distribution
4 feet–1200 mm	2 x base cabinets (600 mm)
5 feet-1500 mm	1 base cabinet (900 mm) + 1 base cabinet (600 mm)
6 feet–1800 mm	2 x base cabinets of (900 mm)

3. Acid and Alkali Storage Base Cabinet:

a. Base units under hoods shall be fabricated of cold rolled steel zinc protected cold rolled steel of 21 gauge (0.8 mm), epoxy coated.
b. 18 mm thick double wall door with 270º opening hinges. Unit floor and to base shall have a grille for natural ventilation. Cabinet can be vented through the fume hood exhaust duct. Each cabinet shall be labelled "ACID" or "ALKALI"
c. The units shall be equipped with 1 tray made of polypropylene for acids and 1 tray made of polypropylene for alkalis.
d. Cabinets shall incorporate a to base of 120 mm to support the unit.
e. Dimensions :

1200 mm	2 x base cabinets (600 mm)
1500 mm	1 base cabinet (900 mm) + 1 base cabinet (600 mm)
1800 mm	2 x base cabinets of (900 mm)

Without base (bench mounted)

PART 3 EXECUTION

(3.1.) SITE EXAMINATION

(A) The owner and/or representative shall certify building conditions conductive to the installation of a finished goods product, including dimensions for the installation of the hoods.

(3.2.) INSTALLATION

(A) Before beginning installation of fume hood, check and verify that no irregularities exist that would affect quality of execution of work specified.
(B) Work in close cooperation with associated trades installing ductwork, wiring and other services.
(C) Install fume hoods in proper location according to manufacturer's instructions and approved shop drawings.

(3.3.) ADJUST AND CLEAN

(A) After installations are complete, adjust, remove and replace all equipments for its intended use.
(B) Clean equipment and surfaces, rendering all work in an unused appearance.

(3.4.) PROTECTION

(A) Provide all necessary protective measures to prevent casework and equipment from being exposed to other construction activity.

(5.10.).II. LABORATORY CASEWORK:

PART 1 GENERAL

(1.1) SCOPE OF WORK:

- All laboratory casework, working surfaces and other items specified herein and shown on the drawings shall be furnished and installed and shall be demonstrated to properly perform in accordance with the functions specified herein. Provide all necessary fillers, scribes and miscellaneous accessories and hardware to provide a complete installation.
- The Contractor should make allowances for an official site visit to the country of manufacture of the laboratory furniture for Three professional KISR Engineers in order to approve and check the quality of the factory and evaluate its products. The visit should be an all paid expenses 18including tickets & reservation of flight, all transportation in and out of Kuwait, and KISR Engineers stay should be in a five star hotel for 7 days.

(1.2.) SECTION INCLUDES:

(A) Laboratory casework systems
(B) Metal
(C) Steel casework
(D) Work surfaces

(E) Shelves
(F) Service columns
(G) Sinks
(H) Electrical Services
(I) Service Fixtures

(1.3.) RELATED SECTIONS

(A) Section 11610.1: Laboratory Fume Hoods (horizontal mounted service fixtures)
(B) Section 11610.2: Laboratory Fume Hoods (vertical mounted service fixtures)

(1.4.) DELIVERY, STORAGE AND HANDLING

A. Schedule delivery of casework and equipment so that spaces are sufficiently complete to allow for installation immediately following delivery.
B. Protect finished surfaces from soiling or damage during handling and installation. Protect all work surfaces from damage throughout construction period. Mark in large lettering "NO STANDING" to not allow standing on work surfaces during the construction period.

(1.5.) PROJECT CONDITIONS

(1) Do not deliver or install equipment until the following conditions have been met:
(2) Windows and doors are installed and the building is secure and weather tight. Ceiling grid, overhead ductwork, and lighting are installed.
(3) All painting is completed and sheet vinyl is installed.

(1.6.) SUBMITTALS

(A) **Product Data**: Submit manufacturer's data for each item of laboratory furnishings and equipment. Include component dimensions, configurations, construction details, joint details and attachments. Indicate location, size and service requirement for each utility connection.
(B) **Shop Drawings:**
(1) Provide 1 = 50 (metric) scale elevations of individual and battery of casework units showing cross sections, rough-in. Indicate relation of units to fume hoods, other laboratory equipment, walls, windows, doors and other building components.
(2) Provide one sets of prints.
(C) **Top Samples:** Submit 100 mm (4") x 100 mm (4") product sample of each type of work surface.
(D) **Hardware Samples:** Provide samples of door and drawer pulls.
(E) Finish Samples: Submit 60 mm (2 3/8") x 100 mm (4") samples of casework finish from manufacturer.

(1.7.) QUALITY ASSURANCE

A. Single Source Responsibility: Laboratory casework, work surfaces, Laboratory Sinks, Electrical and Service Fixtures, and accessories specified as part of this section and Section 11601 Laboratory Fume Hoods shall be furnished by a single laboratory furniture supplier. Proposals from brokers or multiple furniture suppliers will not be accepted.

B. The supplier for work in this section shall use an established manufacturers production facilities including all tools, equipment and special machinery necessary for specializing in the fabrication and installation of the type of equipment specified, with skilled personnel, factory trained workmen and an experienced engineering department. Each shall have the demonstrated knowledge, ability and the proven capability to complete an installation of this size and type within the required time limits:

1. Ten years or more experience in manufacture of laboratory casework and equipment of type specified.
2. Ten installations of equal or larger size and requirements within the last five years.

(1.8.) REFERENCES

A. American Society for Testing and Materials (ASTM):

1. 2.	ASTM B499 ASTM 2794	Test method for measurement of coating thickness Compliance of standard test method for resistance of organic coating to the effect of rapid deformation
3.	ASTM D3359	Measuring adhesion by tape test
4.	ASTM D522	Standard Test method for mandrel bend test of attached organic coatings
5.	ASTM D522	Standard practice for operating salt spray

B. British Standard (BS):

1.	BS 3900	Paint. Film thickness
2.	BS 5411	Metallic and related coating. Measurement of coating thickness.

C. Deutches Institute For Normung (DIN):

1.	DIN 17140	Specification for Steel. Cold rolled sheet. Quality.
2.	DIN 50981	Measurement of coating thickness
3.	DIN 53151	Test of adhesion of paint

PART 2 PRODUCTS

(2.1.) LABORATORY CASEWORK SYSTEMS

A. Manufacturer:

1. Design of C-Frame laboratory casework is based on products manufactured by Flores Valles S.A. All casework shall be the product of one manufacturer. Equal products of other manufacturers may be supplied provided they meet the product characteristics specified.

Include for projects with prior approvals required.

Need approval by architect 10 days prior to bid.

B. "C" Frame System Design Requirements:

1. System to provide a flexible and functional system for support of cabinets, wall mounted cabinets and work surfaces.

2. System shall allow horizontal positioning and removal, relocation and reinsertion of cabinets without removal or requiring additional temporary support of the work surface.

3. System shall allow horizontal sliding movement of the cabinet without effort along all the bench length. Frame assembly shall have rail installed under the work area so that under bench units can be easily moved along these rails for the entire length of the bench frame assembly)

4. Framing shall be of any desired length, with table frame supports spaced maximum 1828 mm (6'-0") on center.

5. "C" frame units shall be available in two heights 720 mm (28 3/8") for sitting height and 900 mm (35 7/16") for standing height.

6. Flexible Cabinet Relocation:

a. 500 mm (19 11/16") deep flexible cabinets relocatable without interference of C-Frame leg assembly.

7. Clearances :

a. Flexible cabinets to floor: Minimum 195 mm (7 11/16") for ease of cleaning and floor maintenance.

b. Space behind flexible cabinets and between vertical support members: minimum 145 mm (5 11/16") for services, waste and electrical lines.

8. System shall support sinks when sink cabinets are not required

9. System shall permit use of commercial pipe support and hangar devices.

10. Cabinet fastening devices cannot be accidentally released from framing system. Intentional release can be easily accomplished without disturbing the cabinet contents and without the use of special tools.

C. Performance Requirements:

1. Structural Requirements:

a. Table frame support: Capable of supporting the following loading with maximum flex of 2.4 mm (3/32") of front upper rail at the center of four feet frames 1200 mm (47 1/4") with shelves :

(1) Counter top material with Equipment, apparatus and personnel sitting on work surface: max. 258 kg/ml (174 lbs./ln.ft.)

(2) Flexible cabinet loading: max. 100 kg/ml (67 lbs./ln.ft.)

b. Wall mounted cabinets attached to uprights: min. 150 kg/ml (101 lbs./ln.ft.)

2. C-Frame System:

a. Steel tubing for formed members and reinforcing: Minimum 4 mm (8 gauge) cold rolled steel.

b. Steel angle at bottom rear of cabinets for support and sliding system (skate): 460 mm (18 1/8") or 960 mm (37 13/16") length, 4 mm (8 gauge) steel angle.
c. Connecting bolts: M6 steel bolts; bolts, nuts and washers: nickel
d. Levelling devices: M10, 35 mm (1 3/8") long zinc steel stems, base of diameter 25. Black technopolymere base. Provide two per each C-Frame leg assembly.

(2.2.) METAL FINISH

A. Metal Finish:

1. Preparation: Degreased clean metal, electrolytic zinc settlement, pretreat with phosphate, chromated treatment, gradually cooled and degreased prior to application of finish.

2. Application: Electrostatically apply powder coat and bake in controlled high temperature oven to assure a smooth, hard satin finish. Surfaces shall have a chemical resistant, high grade laboratory furniture quality finish of the following thicknesses:

a. Exterior and interior surfaces exposed to view: 0.05 mm minimum average (2 mil)
b. Backs of cabinets and other surfaces not exposed to view: 0.05 mm minimum average (2 mil)

3. Harmonizing finish drawer bodies and apply corrosion-resistant treatment to selected, concealed interior parts.

B. Metal Finish Performance:

1. Metal finish performance requirements:
a. Adherency : Excellent. Without any coating detachment.
b. Embutition Ericksen : Embutition of 7 mm. depth without any coating cracks.
c. Flexibility : No cracking or loss of adhesion at bend at 180º
d. Impact Resistance: Satisfactory with one bowl of 1 kg thrown from 30 cm to 60 cm height. No cracking
e. Salt environment : No visible effect to surface finish following 500 hour after application of NaCl (5% concentrated)
f. Humidity resistance: Withstand 1000 hour exposure in saturated humidity with no loss of adhesion or blistering.
g. Distilled water resistance: Withstand 240 hour exposure in distilled water at 40 degreesC.

h. Water vapors: No visible effect to surface finish following 1 hour continuous water vapors
i. Hot water: No visible effect to surface finish following 2 hours continuous boiled water.

1. Chemical resistance:
a. Test procedure: Apply 10 drops (approximately 0.5 cc) of each reagent identified on the surface of the finished test panels laid flat and level on a horizontal surface. Ambient temperature: 68-72 degrees F (20-22 degrees C). After one hour flush away

chemicals with cold water and wash surface with detergent and warm water at 140 degrees F (65.5 degrees C) and with alcohol to remove surface stains. Examine surface under 100 foot candles of illumination.

b. Evaluation ratings: Change in surface finish and function shall be described by the following rating:

2. No effect: No detectable change in surface material.
3. Excellent: Slight detectable change in color or gloss, but no change to the function or life of the working surface material.
4. Good: A clearly discernable change in color or gloss, but no significant impairment of working surface function or life.
5. Fair: Objectionable change in appearance due to surface discoloration or etch, possibly resulting in deterioration of function over an extended period of time.
6. Failure: Pitting, cratering or erosion of working surface material. Obvious and significant deterioration.

a. Minimum acceptable results (concentration by weight)

CHEMICAL	RATING
Sodium Hydroxide, 10%	No effect
Sodium Hydroxide, 25%	No effect
Hydrochloric Acid, 37%	Excellent
Nitric Acid, 25%	Excellent

CHEMICAL	RATING
Nitric Acid, 60%	Good
Phosphoric Acid, 75%	Excellent
Sulfuric Acid, 28%	Excellent
Sulfuric Acid, 85%	Good
Ammonium Hydroxide, 10%	Excellent
Carbon Tetrachloride	No effect
Ethyl Acetate	Excellent
Acetone	Good
Ethyl Alcohol	Excellent
Ethyl Ether	Excellent
Acetic Acid, 93%	Good
Formic Acid, 33%	Good
Formaldehyde, 37%	Excellent
Hydrogen Peroxide, 5%	No effect
Methylethyl Ketone	Excellent
Phenol, 85%	Good
Xylene	Excellent

(2.3.) STEEL LABORATORY CASEWORK

A. Manufacturer:

1. Design of steel laboratory casework is based on products manufactured by Flores Valles S.A. All casework shall be the product of one manufacturer. Products of equal manufacturer may be supplied provided they meet the product characteristics specified.

Include for projects with prior approval required.

For manufacturers not listed, submittal for approval must be to the Architect 10 days prior to bid. No exceptions.

B. Design Requirements:

1. Flush construction: Surfaces of doors, drawers and panel faces shall align with cabinet fronts without overlap of cabinet ends, top or bottom rails. Horizontal and vertical cabinet shell members shall meet in the same plane without overlap.
2. Back Panels: used for the entire length of the casework to enclose the rear portions of an area to cover the plumbing space.
3. Self supporting units: Completely welded shell assembly without applied panels at ends, backs or bottoms, so that cabinets can be used interchangeably or as a single, stand –alone unit.
4. Interior of units: Easily cleanable, flush interior. Base cabinets, 900 mm, with double swinging doors shall provide full access to complete interior without center vertical post.
5. Drawers: Sized on a modular basis for interchange to meet varying storage needs and designed to be easily removable in field without the use of special tools.

C. Performance Requirements:

1. Structural performance requirements: Casework components shall withstand the following minimum loads without damage to the component or to the casework operation:

a. Suspended flexible units: 100 kg (220 lbs.)
b. Floor Mounted units: 300 kg (600 lbs)
c. Drawer in a cabinet: 25 kg (55 lbs.)
d. Hanging wall mounted cabinets: 75 kg (165 lbs.)
e. Load capacity for internal shelves of mobile units, wall mounted cabinets and tall cabinets: 30 kg (66 lbs.)

2. Metal Finish Performance Requirements: Refer to 2.1 C, Item 3, Performance Requirements.

C. Materials and Finishes:

1. Sheet Steel: Cold rolled steel electrostatically zinc coated.

2. Minimum gauges :

a. 0.8 mm (21 gauge) to 1.5 mm (16 gauge):: Interior and exterior panels, drawer and door fronts and backs (double wall), drawer body, cabinets top, end, bottom, base, back, utilities access panels, and internal cabinets shelves, cabinet frame, table legs and frames, leg rails and drawer angle support.

b. 4 mm (8 gauge): Drawer guides, cabinet channel rail , cabinet skate

3. Glass (for glass display tall cabinets or glass display wall cabinets):

a. 6 mm (1/4”)

Glass (for shelve surface) :

b. 6 mm (1/4”), steel armed glass

Glass to be without imperfections or marred surfaces

4. Metal finish: Refer to 2.2 Metal Finish

E. Construction:

1. Flexible Units, Wall Mounted Cabinets and Tall Cabinets:

a. Flexible units and 750 mm (29 1/2”) high wall mounted cabinets: Front reinforced with lintel, back and side with rivet.

b. 2000 mm (78 3/4”) tall cabinets : Front reinforced with lintel, back and side with rivet. Upper corner reinforcement.

c. Shelf : adjustable internal shelf system. Holes in back panel and front frame shall be perfectly aligned for level setting, 70 mm (2 3/4”) up and down from the center.

d. Flexible unit backs: provide fixed backs at all drawer and cupboard units. The sink units shall have partial back panel to allow access of drain line and piping to the service chase.

2. Drawers:

a.Drawer fronts: 18 mm (11/16”) thick, double wall construction, pre-painted prior to assembly and sound deadened; top front rounded.

b. Drawer bodies: Bottom, sides and back formed into one-piece center section with bottom and sides coved and formed top edges. Front panel riveted to center section.

c. Drawer suspension: Heavy duty coved guides for drawer with nylon tired, ball bearing rollers; self-centering and self-closing when open to within 100 mm (4”) of the closed position.

d. Provide drawer with rubber bumpers. Friction centering devices are not acceptable.

e. File drawers: provide with full extension slides for full access and operation.

3. Doors:

a.Solid panel doors and Solid Swinging doors: 18 mm (11/16”) thick, double wall, steel construction with interior pre-painted and sound deadened. Door panel reinforced 1.5 mm (19 gauge) where secure hinges are screwed. Hinges shall be removable; welding of hinges not acceptable. Doors shall close against rubber bumpers.

b. Unframed sliding glass doors: 6 mm (1/4”) glass with pulls and bottom extruded aluminium track. 3 mm (1/8”) thickness side track to prevent shock at fully opened and closed door position.

4. Adjustable Steel Cabinet Shelves:
a. Whole shelf 22 mm (7/8") thickness in steel with PVC coating
b. Entire length of shelves: from 594 mm for 600 mm wide cabinets to 894 for 900 mm wide cabinets and 1093 mm for 1200 mm wide cabinets.

5. Hardware:
a. Drawer and hinged door pull handles: high chemical strength aluminium with epoxy coating. Screwed. Color options
b. Drawer and hinged door label holders: high chemical strength aluminium with epoxy coating. Screwed. Color options
c. Sliding glass door pulls: Rounded pull, high chemical strength Polyamide with fiberglass.
d. Hinges: 270º opening hinges; Nickel plated self-closing. Provide two hinges for doors up to 1052 mm (41 7/16") high; three hinges for doors over 1052 mm (41 7/16") high.

6. Flexible casework (suspended casework) : 480 mm (18 7/8") and 660 mm (26").
a. Provide finish back on all flexible cabinets (suspended cabinets).
b. Do not provide toe base on flexible cabinets (suspended cabinets).
c. All flexible cabinets (suspended cabinets).shall have tops except sink cabinets.
d. Hanging sliders: Two suspending cabinet brackets in polyamide of 12.5 mm (½") fixed to the reinforced steel cabinet frame.
e. Skate : One bracket with wheels at the bottom rear of the cabinet to permit total and effort less horizontal movement along the whole size bench without removal of working surface and without restriction or limitation of "C" frame leg assembly.

(2.4.)WORK SURFACES

Delete all surface types that are not applicable.

A. Epoxy Resin Work Surface:

1. Material: Chemically and abrasion resistant, durable top of 25 mm (1") thick cast material of epoxy resins and inert products, cast flat, with a uniform low-sheen black surface.

Edit the following to meet project requirements. Minimum epoxy resin backsplash height is 50 mm (2")

2. Backsplash curb:

Select from the following:

a. Same material as top, 50 mm (2") high. Butted to top and cemented to top. Provide where tops above all surfaces, include end curb where top abuts end wall.

b. PVC, 70 mm (2 3/4") high. Butted to top and attached to wall surface with screws. Apply silicon caulk at intersection of backsplash and countertop.

B. Phenolic Resin Work Surface (Trespa):

1. Material: Compressed layers of thermosetting synthetic resins, reinforced by cellulose fibre. The top layer is specially made to increase resistance to chemical reagent. Thickness 20 mm (3/4")

2. Backsplash curbs:

Select from the following:

a. Same material as top, 50 mm (2") high. Butted to top and cemented.
b. PVC, 70 mm (2 3/4") high. Butted to top and attached to wall surface with screws. Apply silicon caulk at intersection of backsplash and countertop.

E. Stainless Steel Work Surface:

1. Material: 1.5 mm (16 gauge) or 1 mm (19 gauge) Type 304 stainless steel with No. 4 polished finish on all exposure surfaces and edges.
2. Tops:

Select from the following:

a. 1 mm (19 gauge) Type 304 stainless steel. Front top 40 mm (1 9/16") and waterproof agglomerate to underside for hardness.
a. 1.5 mm (16 gauge) Type 304 stainless steel with steel reinforcing channels applied to underside as required for rigidity and sound dampening. Front top 40 mm (1 9/16").
a. 1.5 mm (16 gauge) Type 304 stainless steel with steel reinforcing channels applied to underside as required for rigidity and sound dampening. Front top 40 mm (1 9/16"). With backsplash incorporated. Form edges, flanges and curbs integrally with top, from one sheet of metal.

F. Post formed Melamine Work Surface :

1. Material: Thermo-setting phenolic and melamine resin sheet of high quality meeting UNE-53173 Standard. 30 mm (1 3/16") thick. Form waterfall edge for front and band exposed side edges with PVC 3mm (1/8") or Formica 1 mm (1/32")
2. Backsplash curb: PVC, 70 mm (2 3/4") high. Butted to top and attached to wall surface with screws. Apply silicon caulk at intersection of backsplash and countertop.

G. Work Surface Performance Requirements:

1. Test procedure: Apply five drops of each reagent to surface and cover with 25mm watch glass, convex side down; test volatiles using one ounce bottle stuffed with saturated cotton. After 24 hour exposure flush surface, clean, rinse and wipe dry.

2. Evaluation Ratings: Change in surface finish and function shall be described by the following ratings:

a. No effect: No detectable change in surface material.

b. Excellent: Slight detectable change in color or gloss, but no change to the function or life of the work surface material.

c. Good: Clearly discernible change in color or gloss, but no significant impairment of work surface function or life.

d. Fair: Objectionable change in appearance due to the surface discoloration or etch, possibly resulting in deterioration of function over an extended period.

e. Failure: Pitting, cratering or erosion of work surface material; obvious and significant deterioration.

Select from the following:

3. Test Results – Epoxy Resin Work Surface:

REAGENT		RATING
Hydrochloric Acid	37%	Excellent
Sulfuric Acid	33%	No effect
Sulfuric Acid	77%	No effect

REAGENT		RATING
Sulfuric Acid	96%	Failure
Formic Acid	90%	Excellent
Nitric Acid	20%	Excellent
Nitric Acid	30%	Excellent
Nitric Acid	70%	Good
Hydrofluoric Acid	48%	Fair
Phosphoric Acid	85%	No effect
Chromic Acid	60%	Failure
Acetic Acid	98%	Excellent
3 & 8 Equal Parts		Excellent
Ammonium Hydroxide	28%	No effect
Sodium Hydroxide	10%	No effect
Sodium Hydroxide	20%	No effect
Sodium Hydroxide	40%	No effect
Sodium Hydroxide Flake		No effect

Sodium Sulfide	Excellent
Zinc Chloride	No effect
Tincture of lodine	Excellent
Silver Nitrate	No effect
Methyl Alcohol	No effect
Ethyl Alcohol	No effect
Butyl Alcohol	No effect
Benzene	Excellent
Xylene	No effect
Toluene	Excellent
Gasoline	No effect
Dichlor Acetic Acid	Good
Di Methyl Formamide	Excellent
Ethyl Acetate	No effect
Amyl Acetate	Excellent
Acetone	Excellent
Chloroform	Excellent
Carbon Tetrachloride	No effect
Phenol	Excellent
Cresol	Excellent
Formaldehyde	No effect
Trichlorethylene	Excellent

REAGENT	RATING
Ethyl Ether	Excellent
Furfural	Good
Methylene Chloride	Excellent
Mono Chlor benzene	Good
Dioxane	Excellent
Methyl Ethyl Ketone	Excellent
Acid Dichromate	Fair
Hydrogen Peroxide	No effect
Naphthalene	Excellent

3. Test Results – Phenolic Resin Work Surface :

REAGENT		RATING
Hydrochloric Acid	37%	No effect
Sulfuric Acid	20%	No effect
Sulfuric Acid	50%	No effect
Nitric Acid	20%	No effect

Nitric Acid	50%	No effect
Acetic Acid	30%	No effect
Acetic Acid	80%	No effect
Ammonium Hydroxide	28%	No effect
Sodium Hydroxide	10%	No effect
Sodium Hydroxide	50%	No effect
Methyl Alcohol		No effect
Benzene		No effect
Acetone		No effect
Phenol		No effect

3. Test Results – Continuous Ceramic Work Surface:

REAGENT		RATING
Hydrochloric Acid	10%	No effect
Hydrochloric Acid	37%	No effect
Sulfuric Acid	30%	No effect
Sulfuric Acid	98%	No effect

REAGENT		RATING
Nitric Acid	10%	No effect
Nitric Acid	65%	No effect
Fluoric Acid		Fail
Formic Acid	100%	No effect
Acetic Acid	98%	No effect
Ammonium	32%	No effect
Sodium Carbonate	20%	No effect
Sodium Chlorite	10%	No effect
Methyl Alcohol	100%	No effect
Ethyl Alcohol	10%	No effect
Benzene		Excellent
Di Methyl Formamide	100%	No effect
Acetone	100%	No effect
n-Heptane		No effect
Ethylene Dichloride		No effect
Peroxygen	30%	No effect

(2.5.) SHELVING

A. Bench Shelving: Self-standing shelving. Single faced unit at wall benches, double faced unit at center benches; open front or enclosed as indicated; height and depth

of units as indicated. Services accessibility and flexibility by interchangeable steel panels system.

Select from the following:

1. Shelves without services : Shelving fixed to self-standing uprights. Open front
1. Shelves with vertical services in column : Shelving fixed to self-standing uprights. Open front and Service fixtures fixed vertically in columns on interchangeable steel panels.
1. Shelves with mid-horizontal services in panels : Shelving fixed to self-standing uprights. Mid-open front and Service fixtures fixed horizontally on interchangeable steel panels.
1. Shelves with full-horizontal services in panels : Shelving fixed to self-standing uprights. Closed front and Service fixtures fixed horizontally on interchangeable steel panels.

2. Uprights: 30 mm (1 3/16") x 150 mm (6") extruded aluminium vertical profiles, protected by an epoxy covering. With channel rail for screw access.
3. Panels: 200mm high (7 7/8") for mid-horizontal shelving or 400mm high (15 3/4") for full-horizontal shelving.
4. Shelf : 6 mm (1/4") safety glass thickness on metal frame. Surface storage of 150 mm (6") depth or 225 mm (8 7/8") or 300 mm (11 7/8") available.
5. Shelf lips: Back retainer strip of PVC of 2 mm (1/16"). Front top lip of 40 mm (1 9/16") high extruded aluminium for glass stability.
6. Hanging light attachment system or hanging distillation grid attachment system with wing nuts on side support brackets where indicated.

D. Wall Shelving :

1. Wall Shelves with services in panels: Placed against the wall. Shelving fixed to self-standing uprights. Open or closed front upper part and closed front lower part. Service fixtures fixed horizontally on interchangeable steel panels.

(2.6.) SERVICE COLUMNS

A. Service columns shall be furnished and installed in case of services supplied from ceiling. 300mm (8 7/8") width x 150mm (6") depth with 3500mm height (137 3/4").Height adjustable according to ceiling. With panels of 400mm high (15 3/4")

(2.7.) SINKS

- Sinks and drip cups shall be of the size shown on drawing. Color shall match with work surface. Sink bowls shall be furnished with sink outlets. Sink tops shall have raised edges on all four sides. Sinks shall be composed of a single bowl or a bowl and a drainer as indicated on drawing.

Delete all sink types that are not applicable.

1. Epoxy Sink: Made of moulded and cured epoxy resin with chemical resistant properties. High resistant to acids, bases, salts and solvents.
2. Ceramic Sink: Made of vitrified ceramic with chemical resistant properties. Resistant to acids, bases, salts and solvents.
3. Polypropylene Sink: Made of Polypropylene with chemical resistant properties, except some specific solvents.
4. Stainless Steel Sink: Made of stainless steel 304 or 316 type.
5. Drip cups: Made of moulded and cured Polypropylene (black or grey color) with acid resistant properties or Ceramic.

(2.8.) ELECTRICAL SERVICES

The following are for general guide lines when Electrical services are required for Laboratory Flexible System.

A. Electrical Services to be mounted on electrical shelve raceway or on work surface (located on back splash).
B. The Electrical sub-contractor will supply the following items to the Laboratory furniture manufacturer for benches:

- 13A 240V 50Hz switched socket BS outlets with back boxes, 16A 250V switched socket French and German outlets with back boxes or 15A/20A NEMA Standard US outlets with back boxes.
- RJ11 Telephone Outlets with back boxes
- RJ45 Computer Outlets with back boxes

C. Refer to B.O.Q. and drawings for location of the electrical services required for each bench. And co-ordinate with sub-contractor for pick-up points.
D. Sockets shall be switched socket of country required type (BS, German, French, US…)
E. Outlets shall be fixed to back boxes, which shall be flush/trunk mounted and it shall be single or duplex as indicated on the drawing.

(2.9.) SERVICE FIXTURES

A. The fixtures shall be supplied in accordance to B.S. 5750, B.S. 5412 & DIN and approved, long life, easy operation, easy cleaning and of high degree of flexibility and tested quality.

1. The surface to be plastic coating resistant to chemicals, heat and localized shut off, presenting and safety lock.
2. Hot and cold water service fixtures: The fitting shall be one piece construction from brass and deck mounted. The surface coating shall be chemical resistant. The fitting shall be provide only at sink units using mixing faucets with gooseneck.

3. Cold water service: The fitting shall be one piece construction from brass and deck mounted. Gooseneck fixture, provide for use with cup sinks shall be located considering the best manipulation.
4. Gas, Compressed Air and Vacuum service: The fitting shall be one piece construction from brass. The surface coating shall be chemical resistant and heat, etc.
5. Safety Shower with Eye Wash: The assembly shall consist of 10 inch shower head of ABS (cycolac) plastic or stainless steel, shower valve, bowl of ABS (cycolac) plastic or stainless steel, 10 inch size for eye wash with 2 sprays.
6. Service Fixtures handles shall be color coded by type of service in accordance with DIN 12920

Description	*Color Code*
Water Gas	Green Yellow
Compressed air	Blue
Vacuum	Grey

B. Materials of piping

1. Water, gas, compressed air and vacuum system pipe work shall be copper according to UNE 37116-81 Standard

PART 3 EXECUTION

(3.1.) INSTALLATION

A. Casework Installation:

1. Install system in strict accordance with manufacturer's instructions.
2. Set system components plumb, square, and straight with no distortion. Shim are required using concealed shims.

B. Work Surface Installation:

1. Where required due to field conditions and top material, scribe to abutting surfaces.
2. Only factory prepared field joints, located per approved shop drawings, shall be permitted. Secure joints in field, where practical, in the same manner as in factory, with dowels, splines, adhesive or fasteners recommended by manufacturer.
3. Secure work surfaces to casework and equipment components with material and procedures recommended by the manufacturer.
4. Abut top edge surfaces in one true plane. Provide flush joints. Not to exceed 3 mm (1/8") between top units at epoxy resin.

C. Accessory Installation: Install accessories and fittings in accordance with manufacturer's recommendations. Turn screws to seat flat; not to drive.

(3.2.) ADJUSTING

A. Repair or remove and replace defective work, as directed by Owner's Representative upon completion of installation.

B. Adjust doors, drawers, hardware, fixtures and other moving or operating parts to function smoothly.

(3.3.) CLEANING

A. Clean shop finished casework, touch up as required, wipe down and broom clean interior and exterior of equipment.

(3.4.) PROTECTION OF FINISHED WORK

A. Provide all necessary protective measures to prevent exposure of casework and equipment from exposure to other construction activity during installation.

B. Advise contractor of procedures and precautions for protection of material, installed laboratory casework and fixtures from damage by work of other trades.

SECTION - 4(G)

TECHNICAL SPECIFICATIONS - MECHANICAL WORKS

SPECIFICATIONS : INDEX

LIST OF DRAWINGS:

For list of drawings and schedule of equipment refer to the first drawing of each service.

SECTION – 4G.1

AIR CONDITIONING AND VENTILATION WORKS.

CONTENTS

SECTION – 4G.1
AIR-CONDITIONING AND VENTILATION WORKS SPECIFICATION

1. GENERAL CONDITIONS

1.1 The schemes covered under these specifications call for supply and installation, setting to work, testing, commissioning and delivering in perfect operating condition as well as maintaining the installations for a period as mentioned in the main Contract Conditions from the date of testing and acceptance as detailed in the Book of General Conditions of Contract, conditions of adjudication to tenderers participating in the MEW tenders calling for supply and installation issued by MEW.

1.2 Specifications described hereunder are brief and therefore the tenderer shall include for all the equipment, materials, labor, etc. for the complete installation to ensure best workmanship and operating conditions, whether detailed under the specifications or not. The contractor shall carry out without extra charge, any work required to meet the job conditions.

1.3 All builders' works including foundations, cutting, opening, steel supports, etc. required for the installations shall be done by the contractor whether mentioned hereunder or not.

1.4 Where equipment offered are manufactured under license, tenderers shall enclose with their offers a written assurance from their principal for the design and quality of equipment produced by them without which the offers shall not be considered.

1.5 Where equipment offered are manufactured locally, thetenderers shall produce the relevant design data for scrutiny.

1.6 All electrical works shall conform to the regulations governing electrical installation works issued by MEW.

1.7 Approval of design, material, equipment, systems, layout, etc., doesnot relieve the contractor from his contractual obligations if later on found that they do not comply with specification requirements.

1.8 If the contractor during the guarantee and maintenance period fails to respond to any necessary repairs call within 24 hours after the contractor being notified by phone or Fax, MEW reserves the right to execute the necessary

repairs under full responsibility of contractor and charge the contractor the cost of these repairs without accepting any claims from the contractor's side.

1.9 If the contractor is not the main agent of the A/C equipment and if contractor fails to start and commission the A/C equipment, MEW reserves the right to call a specialist from the main local agent to start and commission the A/C equipment at the expense of the contractor without any claims from the contractor's side.

1.10 All refrigeration machines offered by the contractor should be energy efficient. Equipment with a better Coefficient of Performance (COP) will be preferred during the adjudication of tender.

1.11 The contractor shall submit the electrical installation test form to the Ministry of Electricity & Water before the unit is connected to the main power supply.

1.12 Contractor should adhere to the equipment offered in histender documents. Contractor is not allowed to change from the equipment offeredand he should make sure during tendering stage that the equipment he is offering can be obtained within the period of the contract. MEW will not entertain any claims at a later stage, on account of delay in delivering the equipment.

1.13 The contractor shall prepare necessary working drawings, mechanical, electrical and civil, and submit to MEW for approval within 8 (Eight) weeks of signing the contract. No installation work shall be permitted to commence before the approval of the working drawings.

1.14 The equipment should be of reputable manufacturer, which has been in satisfactory operation of not less than 3 years in Kuwait or similar weather condition.

1.15 The contractor, in addition to the working drawings, shall submit detailed program chart for the execution of air conditioning and all associated services to the engineer for approval (Electrical & Civil). The program must show all works breakdown into their component parts and indicating the phasing of delivery, execution and commissioning to give the completion of the works by the required date.

1.16 All materials shall be the best of their kind. Samples of materials required by engineer shall be submitted for approval within 8 weeks ofsigning the contract.

1.17 The contractor shall ensure that all mechanical, electrical and civil works shall be supervised by qualified engineers of the respective specialization. These engineers shall be available at site during Ministry working hours or as and when required. The list of the contractor's supervisory staff shall be submitted to MEW for approval within 2 weeks of signing the contract.

1.18 The contractor should use locally manufactured equipment and materials wherever possible.

The contractor shall ensure cleanliness and safety of all sites throughout the execution of the project and shall remove all waste materials and debris to location marked by the Municipality for such purposes. No scrap materials shall be allowed to accumulate on site. Removal of such materials shall be carried out at short intervals to avoid any mishap, accident or inconvenience to the users. If the contractor fails to clean the site of such waste and debris within 48 hours after being notified by phone, the ministry reserves the right to carry out necessary cleaning works and charge contractor without accepting any claims.

1.19 Priority will be given to National Products and Products of National Origin as mentioned in the Ministry of Commerce and Industry Ministerial Decree No. (6) of 1987 and subsequent amendment to Para 8 vide Decree No. (23) of 1987 the translation of which are given as appendix to this tender specification. Non-compliance to the above decree shall involve penalty as mentioned therein.

2. SCOPE OF WORK:

2.1 The works shall include, but not limited to supply, installation and guarantee of HVAC system in accordance with the technical specifications, drawings and bill of quantities.

3. DETAILED TECHNICAL SPECIFICATIONS

3.1. Packaged Air Cooled (Screw) Chillers:

General:

The air cooled packaged chiller shall be completely factory assembled including all refrigerant piping, internal wiring and controls, and shall be contained within the unit enclosure. The unit shall be mounted on a steel base and shall be shipped with full operating charge of refrigerant. The casing shall be of heavy gauge galvanized steel sheet with baked enamel finish. The unit shall consist of compressors, air-cooled

condenser, evaporator, refrigerant circuit and controls. The chiller shall conform to:

ARI 590 Reciprocating Water-Chilling Packages (construction, testing and ratings).

ASHRAE 15 – Safety Code for Mechanical Refrigeration (construction and operation).

ASHRAE 90A: Energy Conservation in New Building Design.

ASME Sec. VIII – Boiler and Pressure Vessel Code.

NEMA MG 1 – Motors and Generators.

UL 465 – Central Cooling Air Conditioners (for Construction) UL label to be provided.

The contractor shall ensure that noise level adjacent to chiller compound will not exceed values mentioned in ASHRAE.

3.1.1 Semi-Hermetic Screw Compressor:

Compressors shall be two or more, semi-hermetic screw type comprising the following:

a. Compressor compartment which includes one pair of screw rotors (male and female) supported by roller-bearings on both sides, suction gas strainers, and a capacity control mechanism.

b. Hermetic motor compartment which includes control mechanism, stator and rotor.

c. Oil separator compartment to serve as oil separator and oil reservoir.

The rotor of the hermetic motor shall be directly mounted at the suction end of the male rotor to operate at 2900 RPM (approximate) with 415 V, 3-phase, 50 Hz supply. The motor shall be cooled by suction gas passing around the winding. The compressor shall be provided with suction and discharge stop valves and pressure relief valves.

3.1.2 Air-Cooled Condenser:

The air-cooled condenser shall consist of condenser coil, condenser fans, motors and other accessories.

a. Condenser Coil: The Condenser Coil shall be constructed of seamless copper tubes arranged in staggered rows, mechanically expanded in to Aluminum fins. Both tubes and fins to be precoated by special coat suitable for the environment of the site. The design working pressure for condenser coil shall be suitable for R134a andweather condition and shall be pressure tested at not less than 1.5 times the maximum working pressure.

b. Condenser Fans and Motors: The Condenser Fans shall be propeller type, vertical discharge with safety guards. The fan blades shall be of

aluminum with a center hub of steel and shall be statically and dynamically balanced. The center hub shall be zinc-plated and the entire assembly shall be neat finish. The fan shaft shall be corrosion protected.

c. Each fan shall be direct-driven by an individual motor. The condenser fan motors shall be of drip-proof, Class 'B' insulation as a minimum with permanent lubricated ball bearings. An access panel shall be provided for electric connection for each motor.

d. The Noise Level shall not exceed 50 db at 10 M, unless otherwise specified.

3.1.3 Evaporator:

Evaporator shall be dry expansion, horizontal, shell-and-tube type with removable heads. Shell shall be of seamless or welded steel construction. Tubes shall be seamless copper tubes rolled into the tube sheets. The design working pressure of the cooler shall be suitable for R134a. The cooler shall be covered with factory applied insulation and cladding. The water circuit shall be tested (hydrostatically) at not less than 225 Psi. The maximum water pressure drop across the cooler shall not exceed as mentioned in the Duty of equipment. The Evaporator shall be selected for a fouling factor of not less than 0.00025 $ft^2hr.\ °F/Btu$.

3.1.4 Refrigerant Circuit Components:

The Refrigerant Circuit shall be constructed of seamless copper tubing with brazed joints, factory supplied and piped and shall include hot gas muffler, high side pressure relief valve, liquid line shut-off valve, replaceable core-type filter-drier, moisture indicating sight glass, thermal expansion valve, and liquid-line solenoid valve. The entire suction line and liquid line between the expansion valve and the cooler shall be insulated with suitable type insulation. The refrigerant circuit shall include shut-off valves with charging connection and all other necessary and required components.

3.1.5 Controls:

Control Panel:

Provide a unit mounted microprocessor based control panel ensuring all control and safety functions for automatic operation. Control set point settings accessible without opening the panel door. Display of control parameters, operating and diagnostic codes, Status lights and pressure gauges.

On Chiller IP65 control panel, containing starters power and control wiring, moulded case disconnect switch, factory wired with single point power connection, provide short circuit protection to IEC 157 and wiring to En 60204 – Cable wires and components.

For each compressor, provide part winding starter, non-recycling compressor overload, starter relay, and control power transformer or terminal for controls power. Provide manual reset current overload protection.

Provide safety controls with indicating lights and with terminations for connection to controls system arranged so any one will shut down machine and require manual reset, before restart and,

a. Control fuses
b. On-Off pump down selector switches.
c. Positive acting timer to prevent short cycling of compressors and to delay restart of compressors after shut down (min. 10 minutes), one No. for each compressor.
d. Low pressure switch - adjustable and automatic reset type, for each ref. circuit.
e. High-pressure switch - adjustable and manual reset type for each ref. circuit.
f. Oil pressure safety switch - adjustable and manual reset type, for each compressor.
g. Freeze protection switch - adjustable and manual reset type.
h. Flow switch for chilled water.
i. Crank-case heater for each compressor.
j. Positive head pressure control to effect fan cycling during low ambient temperature.
k. Ambient temperature control to protect the compressors from tripping at high pressure when the ambient temperature is higher than rated.
l. Overload protection for all motors.
m. Internal thermal protection for compressor motor winding.
n. Step controller for capacity control, by loading and unloading of each compressor, or by cycling compressors or by both. Details of capacity control shall be furnished during tendering stage.
o. Protection for each 3-phase motor against phase failure and improper voltage phase sequence.
p. Indicator neon lights for detecting cause of shutdown.
q. Pressure gauges indicating pressure of suction and discharge of each compressor and oil pressure.

3.1.6 Starter

To comply with Electrical Specifications and shall be part of the Unit.

3.1.7 Oils and Refrigerants

All required refrigerants and oil including first charge and subsequent make-ups and recharges during the entire period from commissioning till the completion of guarantee of the chiller shall be provided by the Contractor.

3.2 **Chilled Water Pumps:**

General:

All pumps shall be suitable for the medium to be handled and shall be:

a. Pump shall be suitable for the service and operating pressure ratings.

b. Pump shall operate at stable conditions without pulsation, noise, vibration or cavitation throughout its entire capacity range. The impeller and rotating assemblies shall be statically and dynamically balanced.

c. Pump's operating point shall fall near the point of the maximum efficiency as obtained from manufacturer's published data. Pump will not be approved if it is selected to operate near the end of its curve.

d. Electrical motors shall be suitable for 415V/3 Ph/50 Hz. Motor speed shall not exceed 1500 rpm. Motor shall have ample capacity to prevent overloading when operating at any point on its characteristic curve, and motor starter shall comply with the electrical specifications. Motor insulation shall be Class F. The Motor shall be rated for 1.25 times the Pump rating. (B.HP).

e. Pump casing shall be high tensile strength alloy cast iron or cast steel suitable for the working pressure and shall be provided with plugged connection for casing vent and drain.

f. Impeller shall be of high quality bronze.

g. Shaft shall be of high quality cromium steel or stainless steel and ample size to carry all axial and radial thrust with minimum deflection and shall be provided with mechanical shaft seals. Pump shaft shall be supported by heavy-duty bearings for both radial and thrust load. Bearings shall be ball or roller type and shall be efficiently sealed.

h. Shaft sleeves (if any), eye rings, bolts, and nuts in contact with water to be of suitable quality stainless steel (316).

i. The whole pump assembly to be mounted on cast iron or fabricated steel bed-plate.

j. Chilled water pumps shall be centrifugal end suction type.

3.3 **Air Handling Units:**

3.3.1. General Description:

The AH unit shall be of the same make as that of the chiller. Each unit shall be sectional type and comprise of: intake section, mixing section, cleanable type panel filter section, bag Filter section, coil section, electric heater section, fan section and plenum. The units shall be complete with internal dampers, pipe work, starters and controls.

Each unit shall have the following:

a. ARI Compliance: Test and rate air handling units in accordance with ARI 430 “Standard for Central-Station Air Handling Units” display certification symbol on units of certified models, Rate Coils in accordance with ARI 410.

b. ASHRAE Compliance: Test and rate fans in accordance with ASHRAE Standard 51 – 75 Laboratory methods of testing Fan for rating.

c. NFPA Compliance: Provide air handling unit internal insulation having flame spread rating not over 25 and smoke developed rating no higher than 50 and complying with NFPA 90A Standard for the installation of air conditioning and ventilating system.

d. UL and NEMA compliance: Provide electrical components required as part of Air Handling Units, which have been listed and labeled by UL and comply with NEMA Standards.

e. NEC Compliance: Comply with NFPA – 70, National Electric Code (NEC) as applicable to installation and electrical connections of ancillary electrical components of air handling Units. In case of discrepancy between NEC and MEW Code, the latter shall govern.

f. The bottom frames of the unit sections shall be bolted to the base frame. The width and length of the base frame shall be selected to suit the size and combination of unit section of the relevant unit.

g. The P- trap shall be fitted and installed at the base frame.

h. The tabulated fan static pressure shown in the equipment schedules are approximate and given for guidance only. The contractor must calculate the system static pressure and provide the required fan and motor HP accordingly.

3.3.2. Air Handling Unit Casing:

It shall be double skin construction, air-tight design with a minimum of 40 mm thick insulation in between, curb mounted, suitable to withstand the severe climatic conditions. The insulation material thermal conductivity shall be not more than 0.29 Btu/hr/sq.ft/deg. F/inch thickness, and shall give good sound attenuation. The casing shall be constructed of heavy gauge, mild galvanized steel formed panels, rigidly reinforced with channels. Casing panels shall be removable for easy access.

Access doors shall be provided for maintenance purposes and additional removable panels shall be provided to enable the fan to be removed completely.

The inspection panels shall be tightly sealed, easy to handle and removable. The inspection panels shall be supplied with quick-release fasteners that can be opened by special key or knobs or lockable handles.

The entire casing shall be painted from outside with two coats of corrosion-resistant paint of a type suitable for galvanized surfaces and suitable for semi-marine environment.

In addition to the above, the paint shall be suitable for outdoor conditions.

All cut edges of the galvanized sheet steel casing, including both visible and hidden edges, shall be painted with cold zinc compound paint.

3.3.3 Fresh Air Intake Section:

Outside air filters shall be of permanent heavy-duty metallic cleanable type minimum 4" thickness. Filters shall be sized to perform their duty with a face velocity not more than 300 FPM. and average resistance efficiency of 75% minimum based on ASHRAE Standard 52-76.

3.3.4. Filter Sections:

a. Cleanable Type Panel Filters: 1st Stage (Return Air Filters):

Permanent washable type of 2" thickness and with substantial aluminum frame filters shall be designed for heavy-duty service and large holding capacity. Filters shall be sized to perform their duties with a face velocity not more than 300 FPM and with the initial pressure drop not more than 0.25 inch W.G. at the rated airflow and average arrestance efficiency of 75% minimum based on ASHRAE Standard 52-76.

b. Bag Filter:

It shall be of dry, extended surface pocket type consisting of 16 gauge galvanized steel holding frame and replaceable filter. Holding frames shall be predrilled for convenient assembly into banks and shall be installed to provide service from the air-intake side. Holding frames shall be equipped with factory installed special high temperature gaskets and heavy-duty rotary spring type latches, which fasten across the corners of the filter to force the filter firmly against the gaskets. Replaceable air filters shall consist of rigid rust-resistant metal headers to which individual pockets of filter media are attached. The media shall be made from ultra-fine fiberglass supported on the air leaving side by a protective media backing. The filter shall have a dust spot efficiency of 40-45%.

The bag filter shall be designed for a face velocity of 500 FPM (2.54 m/sec.).

Each filter section shall be supplied with factory fitted magnehelic differential pressure gauge 4" dia. dial with red marking on maximum recommended pressure drop.

NOTE - 1:

All filters shall be installed and arranged in straight bank or V-arrangement depending on each particular location and velocity requirements. Filters shall be installed complete with necessary filter boxes and access doors in the air intake ducts and in such a way to eliminate air leakage in ducts or bypass and to be easily serviceable.

NOTE – 2:

All filters shall be approved and listed as Underwriters Laboratories (UL) class 1 when tested according to UL standard 900 (or equivalent).

3.3.5 Cooling Coil Section:

Shall have multi-row coil, Nos. of rows shall not exceed (6). Each coil shall be provided with drain, automatic air vent, and stainless steel drip-tray 316. The coil shall be of heavy-duty type, tracks extending the full width of the unit to provide slip-in, slip-out coils for ease of service and maintenance.

The coil face velocity shall not exceed 500 FPM.

Coils to be constructed of copper tubes and aluminum fins spaced not more than 10 fins/inch. Coils of fresh air handling units shall be specially treated for corrosion resistance. The headers shall be of copper or copper alloy with brass water connection.

The tubes to be mechanically expanded to the fins. The drain pan shall extend through the length of the coil and shall have drain connections at either end.

The water pressure drop through the coil shall not exceed 15 ft.

3.3.6. Electric heating Coil Section (Where applicable)

Construct and install electric Heating Coils having a capacity as mentioned in the duty. The electric heating coils, and ancillary equipment and controls shall be constructed and installed in accordance with National Electrical Code (NEC) and shall be in accordance with Underwriters Laboratories (UL) Standard, the electrical components shall be listed and labeled by (UL).

The electric heating coils shall have the following specifications:

1. Rated V, & Hz : 415/3ph / 50 C/S.
2. Rated Capacity: See duty.

Multi-stage type.

The electric heating coils shall be mounted on mill galvanized steel tracks for sliding in and out for ease of maintenance

Heating element shall be 80% Nickel and 20% chromium.

Having step controller to prevent stratification when operating at less than full capacity.

Provide primary and secondary safety devices for over temperature protection.

Provide built-in components which shall include the following:

Safety interlocking disconnect switch.

Disconnecting break magnetic contactors.

Transformer with primary fusing per UL.

Pressure type Air flow switch set at 17.5 N/m².

Supplementary circuit fuses.

Separate load and control terminal blocks to accept conductors.

Special construction.

dust and rain tight terminal box.

Manual Reset Thermal Cutout in control circuit in series with automatic switching devices and controls.

Door Interlock switch (to break control circuit).

Time-delay relay.

3.3.7 Fan Section:

a. Fan:

Fans shall be of centrifugal type, double inlet, belt driven, backward curved, heavy duty. The fan section to be constructed of galvanized steel and shall have a formed channel base for integral mounting of fan, motor and casing panels. Fans and bearings are to be mounted on frame, rigidly secured to the channel base. Bearings to be self-aligning, re-greasable type and should have grease line extending to the outer casing of the A/H Unit to enable easy greasing from outside.

Shafts are to be solid steel, turned, ground and polished. Fan wheels are to be keyed to the shaft and should be designed for continuous operation at the maximum rated fan speed and motor horsepower.

Fans and shafts to be selected to operate at least 25% below the first critical speed. Fan wheels and shafts should be statically and dynamically balanced as an assembly. A final vibration test to be given to the entire unit after final assembly.

b. Motors:

Shall be variable frequency controlled type internally mounted, factory installed on slide rails having 2 adjusting screws.

The fan section shall be supplied with:

Inspection cover, belt guard, drain and anti-vibration mountings and also protective screens.

3.3.8 Intake Damper Sections:

Intake damper sections shall be with contra-rotating blades of a torsionally rigid double skin casing. The bearing shall be of glass fiber reinforced nylon. The damper shall be fixed to a connection frame for adjoining directly to the unit casing.

Dampers shall be sectionalized to limit blade length of not more than 1250mm in order to prevent the excess blade warping and to ensure tight closure.

3.3.9 Mixing Sections:

The mixing sections shall consist of two dampers and equal size with parallel rotating blades to guarantee effective mixing. The blades shall be made of a torsionally rigid double-skin construction of galvanized steel sheet. The bearings shall be of glass fiber reinforced nylon. Dampers shall be sectionalized to not more than 1250mm. The dampers shall be manually operated.

3.3.10 Accessories:

2-Way Valve: To be supplied and installed as shown on the drawings.

Manometers: Manometers of suitable type and range to be supplied and installed across each filter and coil section.

Digital type differential pressure for the filters and the coil and differential pressure switches.

AHUs shall have the facility to monitor the operation and the indication of the above items (B.A.S).

3.4 Fan Coil Units

3.4.1 General

Fan coil Units shall be supplied and installed as shown on the drawings. The Units shall be of 3 or 4 rows coil type maximum.

Coils to be suitable for chilled water application; their ratings, duties and types shall be as tabulated in the equipment schedule. The Fan Coil Units shall be selected at medium speed to give the required capacities. They shall generally be in accordance with the following specification.

3.4.2 Cabinets

All Fan Coil Units as listed in the equipment schedule and drawings shall be exposed type.

The exposed type Fan Coil Units shall be complete with outer cabinet including supply and return air grilles.

The cabinet shall be constructed of the best quality heavy gauge steel waterproof and corrosion resistant, acoustically and thermally insulated internally with easily removable access panel and with baked enamel finish and colour to the satisfaction of the Engineer.

3.4.3 Coil

Cooling coils shall be constructed of heavy gauge copper tubes and aluminum fins. The fin spacing shall not exceed 12 fins per inch. Tubes shall be mechanically expanded to the fins. Each coil shall be provided with a manual air vent of an approved type. An insulated S.S drain pan material fitted with a drain connection shall be provided to receive all condensation and drip from internal fittings.

3.4.4 Filters

Filters shall be 25 mm, thick air filter and shall be of the heavy duty, cleanable type having non-ferrous metal wool or other well proven material arranged in a solid frame. The air filter to be located remotely in the return air opening provided in the return air plenum. Exposed type Fan Coil Units shall have the same type of air filters but with a minimum thickness of 12.5 mm.

3.4.5 Fan

The fan shall be of the multi-blade centrifugal type with balanced wheel directly coupled to an electric motor and shall operate at a static pressure as tabulated in the equipment schedule. Noise level generated shall be within the specified limits.

3.4.6 Fan Motor

Fan Motor shall be of the open type suitable for 240V single phase A.C. 50 cycles with thermal protection and shall be silent in operation. Motor shall be of 3-speed type with permanent split capacitor starting and shall generally comply with electrical specifications.

3.4.7 Controls:

Each unit shall be complete with manually selected 3-speed fan control switch with 'OFF' position. The switch shall be suitable for wall mounting for high level and concealed type units. For floor mounted units the switch shall be an integral part of the unit.

3.5 VAV Terminal units

The VAV Terminal unit shall be designed to provide airflow control to maintain temperature requirements of the room. The unit shall be of the pressure independent shut-off with sizes as shown on the drawings. The unit shall operate through a full range of design flow (20%) – 100%) without changing any mechanical component. The unit shall be factory calibrated with field adjustable set points to set the maximum and minimum air quantities. The unit shall consist of casing, basic control unit and thermostat. Thermostats shall be wall mounted type and shall be provided by the VAV Unit manufacturer. Thermostats shall have Summer / Winter change over provision. The basic control unit shall be electric. Wiring for the electric type shall be part of the control system of the HVAC works. The air-flow control device may be either blade type damper constructed of heavy gauge GI sheet or valve type constructed of dye-cast aluminium. The damper shall be pivoted in nylon bushings for easy movements and balanced air pressure forces. The flow control damper shall have linear response operating characteristics to eliminate damper hunting under partial flow conditions. The damper assembly shall have its shaft extending through the unit casing for attachment to damper actuator and linkage for electric type. The damper actuator and linkages shall be factory-furnished, mounted, connected and adjusted. The electric control device shall be equipped with a 24 Volts 50 Hz. actuator.

Each VAV unit shall be provided with flow taps and calibrated charts to permit field calibration and readjustments. Each VAV shall have ARI certified ratings.

The VAV terminal unit casing shall be fabricated from galvanized sheet not lighter than 0.6mm thick. The interior surface shall be acoustically and thermally insulated with 12.5mm glass fiber, surface treated to prevent erosion. The insulation material and its application shall meet the UL standard or an equally approved standard. Where motor and damper are housed inside the unit casing, the casing shall be provided with a quick-opening leak-proof access door to permit adjustment and damper replacement. The casing leakage shall not exceed 2% of the design flow at the rated internal pressure.

The air outlet connection shall be either of the single or the muiltiple round/square outlet type. The multiple outlet connection shall each include a manual locking type balancing damper, pivoted at two points.

The terminal unit shall have provision for hangers from four corners.

3.6 **Sectional Rectangular Tanks (Make-up) / City Water tanks:**

3.6.1 The tank shall be of pressed steel or (GRP) sectional rectangular type with external flanges, hot dip galvanized bolted construction confirming to BS 1564: 1975 with the following specifications:
GRP (According to BS 1984:1997 accepted)

3.6.2 Capacity: See section 1

3.6.3 Liquid: City Water

3.6.4 Materials: The steel used in the manufacture of the plates, stays, cleats and pads for connections shall conform to the requirements to BS 1360: 1972, grade 13 A or BS 1449 Part 1 1972 Material HR 11 and shall be hot dip galvanized (GRP approved).

3.6.5 Dimensions of Unit plates:

The nominal size of unit plates shall be of 1000-mm square or any standard dimensions.

3.6.6 Thickness of unit plates: Shall not be less than 5 mm.

3.6.7 Staying: The sides and ends of tanks shall be supported by stays at the junction of the two or more plates, the stays shall be made from stainless steel rolled sections, and shall be in accordance with BS 1984.

3.6.8 Flanges of plates:

Shall be pressed with a combined double flange at an angle of 45 deg. and 90 deg. to the face of the plate on all four sides, the flanges holed according to the respective position of the plate in the tank and from irregularities. The width of the flanges shall be not less than 45mm, the holes for the bolts shall be suitable for bolts not less than M 14 and the spacing of bolt-holes shall not exceed 76.2mm pitch.

3.6.9 Jointing material: Synthetic rubber suitable for Kuwait weather.

3.6.10 Bolts, studs, nuts and washers:
Shall be made from Stainless steel 316.

3.6.11 Connections:

Flanges to BS10 shall be welded to the outside of the tank plates, connections for vent, filling lines, drain overflow and supply shall be provided also for quick filling and supply shall be provided.

3.6.12 Supports:

All tanks shall be effectively supported in accordance with the manufacturer's recommendations and tolerances. Supports shall be provided continuously under each bottom flange in one direction at 1000mm centers (or according the manufacturer recommendations).

3.6.13 Cover for tanks: Weatherproof pitch cover constructed of minimum 2.5mm thick plates, hot dip galvanized or equivalent and suitably stiffened to support the weight of maintenance personnel.

3.6.14 Manhole: Minimum one per tank, minimum size 600mm dia. shall be supplied with cover.

3.6.15 Internal access ladder: Each tank shall be provided with stainless steel internal access ladder, and shall be adjacent to the manhole. The ladder shall be factory supplied.

3. 6.16 Service ladder: A galvanized steel ladder fixed on the ground to reach the top of the tank shall be provided for each tank to facilitate servicing.

3.6.17 Water level indicator: Float level indicator, the graduation and the position of the float shall be visible from a distance of at least 20 ms.

3.6.18 Earthing system: Earth electrode and ring earthing shall be provided for each tank.

3.7 **Air Separators**

Air separators shall be constructed in accordance with ASME Boiler and Pressure Vessel Code Section VIII, "Unfired Pressure Vessels" or equivalent standard approved by the Engineer. Air separators shall be rated for a working pressure of 150 Psi. and temperature of 120°F.

Air separators shall be installed as shown in the drawings. Air separators, 65-mm and above shall be of steel welded construction with flanges and provision for two or more ½ inch size or larger size air vents.

3.8. **Closed Expansion Tank**

The expansion tank shall be floor mounting type . Shell shall be fabricated steel, designed and constructed as per ASME Section VIII Div 1, suitable for a working pressure of 150 PSIG.The bladder shall be of heavy duty butyl rubber with 150 PSIG pressure rating and shall be removable for inspection.

The following information shall be taken in to consideration before selecting the tank.

System water content (to be calculated by the contractor)

Necessary fill pressures (35 - 65 Psi)
Operating temperature. (44°F - 120°F)

The expansion tank shall be fitted with a safety valve and condensate drain connection for air compartment and air vent and system connection on water compartment.

3.9**Chemical Treatment:**

Chilled Water System

Water treatment for the chilled water system shall be fully automatic type complete with necessary sensors, chemical tank, dosing pump, corrosion inhibitor solution, necessary valves, piping and controls. The materials for the above components shall be suitable for the chemical used. The amount of corrosion inhibitor required shall depend on the system water content and the concentration level of the chemical as recommended by the manufacturer. In addition to the initial filling, chemical for two complete fillings shall be supplied as spare. The proposed system shall be in satisfactory operation in Kuwait for at least five years and should have been approved by MPW/MEW.

3.10 **FANS:**

3.10.1 Wall & Glass Mounted Fan:

Fans shall be of propeller type of completely enclosed design and shall be provided with means to close the air outlet when the fan is OFF and to open when the fan is ON. A draft-proof electricity operated shutter linked to the fan switch shall be provided.

Fans shall be provided with flush fitting exterior grilles and interior panels to conceal the fan. Fan shall be housed in a base, fitted with weathering skirt and treated againstcorrosion. Fans of sizes (diameter) above 300 mm shall be provided with speed regulator or recessed mounting type.

3.10.2 Duct mounted Fans:

Fans shall be aerofoil, axial flow duct mounted type with non-overloading characteristics, high efficiency and quiet operation. The fans shall be of heavy-duty type and durable construction, provided with shut-off dampers to automatically close when the fan is not running.

The casing shall be hot dip galvanized, cylindrical and flanged at each end and provided with an inspection cover to provide access for blades

angle adjustment. The unit shall also be provided with flexible connection, mounting flanges and vibration isolators.

Fan blades shall be of the dye-cast aluminium. Bearings shall be of the permanently lubricated type. The motors shall be highly efficient Class 'F' insulated with IP 55 weather protection.

Fan motor shall be either coupled to the fan shaft or provided with V-belt drive.

3.10.3 Roof Ventilators:

Roof ventilator shall have an axial, centrifugal or mixed flow type fan as indicated in the project documents, housed in weatherproof housing with base plate cover hood. Accessories shall include backdraught shutters, bird guards and factory supplied curbs. All exposed components shall be made of heavy gauge aluminium or strong light weight material to give excellent resistance to atmospheric corrosion and is suitable for use in a wide range of climatic conditions.

The fan shall withstand 300ºC temperature for a period of 60 minutes and shall be approved by KFD for smoke ventilation application.

Motors shall be highly efficient, Class F insulated with IP 55 weather protection.

3.10.4 Centrifugal Fans:

Fans shall be either double inlet width or single inlet single width as indicated in the Project Documents.

Fans having a static pressure of 750 Pa and above shall be backward curved mild steel sheet blades and fans below 750 Pa static pressure can be of the forward curved mild steel sheet blades type.

Fans shall be with or without cabinet housing and available in right-hand or left hand version as indicated in the project documents. The side plates of the cabinet type housing shall be rectangular with provision of impeller removal. The housing shall be provided with a bolted inspection door for large units.

Bearings shall be of the self-aligning self-cooling babbitted sleeve type with adequate oil reservoirs or self-aligning ball type with accessible grease fittings. Fan shaft shall be turned and ground to size from mild steel bars and by-pass shall be provided with screwing wheels and driving pulleys.

Fan motor shall be either unit mounted to mounted on the same base of the fan with the possibility of motor base adjustment.

Motor pulley and Fan pulley shall be adjustable to provide not less than 20 per cent speed variation except for fans with variable inlet vanes.

Fan drive shall be V-belts and pulleys secured to the fan and motor by keys fitted into Key Ways. The motor pulley shall be of adjustable type. The V-belts shall be of the anti-static type suitable for operation in temperatures up to 55 deg. C.

Where standby (Twin) fans are to be provided according to the drawings, the fan section shall be fitted with a tight proof shut-off pneumatically operated dampers interlocked for opposite action, so as to permit the closing of one fan while opening the other and vice versa.

3.11 PIPE WORKS AND FITTINGS

General:

a) They must be installed with a view to an easy and even flow of fluid to and from all apparatuses without air pockets. It should be installed for quick, sure and positive drainage and provisions for quick and noiseless air escapement.

b) All parts of the system must be capable of being vented, air vents shall be provided at the highest points of all risers, vents shall be piped at their points of connection to the piping system and to a visible drain.

c) Piping shall be run, in general, forming right angles with or parallel with walls and neatly spaced, shall be installed so that there is clearance of at least 25 cm, between finished coverings and the adjoining.

d) Piping shall be hung in ceiling void as close as possible to bottom of slabs, beams, etc., maintaining required and co-ordinated head room at all times.

e) Di-electric connections shall be provided for joining two different pipe work materials (or pipes and equipments), in order to isolate cathodically the pipe line or the equipment. These connections shall be rated to withstand the maximum medium temperature and pressure.

f) All necessary line valves for the satisfactory isolation of components and sections of the system are to be supplied and fitted.

g) Bends should be used in performance to elbows wherever possible.

h) Equipments and apparatus shall be installed as to be totally readily accessible for operation and maintenance.

i) Wherever pipe work passes through walls and floors, mild steel pipe sleeves shall be provided sufficient to ensure free movements. In addition, chromium plated floor plates are to be fitted in the office blocks or where directed by the Engineer.

Pipes connected to vibrating machinery shall be isolated from the supporting structure by vibration eliminators designed for supports by hanger rods. Pipes shall be isolated from the vibrating machinery by use flexible metal pipeline connectors of metal to suit the fluids conveyed and the surrounding conditions.

3.11.1 In all lines carrying liquids drain valves shall be installed at all low points in the system at the end of every/primary or secondary/main, at intervals and not more than 75 meters in all horizontal pipe lines, and all equipment positions. The drain connections shall be provided with a drain line leading down with drain cock to the nearest drain pit.

The size of the drain lines and drain cocks shall be: -

For pipelines below 4" dia. the drain line and drain cock shall be 1".

For pipelines 4" dia. and above the drain pipe and drain cock shall be 1.5"

For outside drainage points on 4" & above pipe works drains shall be 2".

Dirt pockets shall be installed on all pipelines, the dirt pockets shall be located in the pipe lines at: -

- All low points in the system.

-Ahead of any rise in the piping.

- At every 120m (max) of level piping with a relative constant demand during design operation.

-At the end of any primary or secondary main.

- Every 60 M (max.) of level, piping with considerable on-off demand during design operation.

- Ahead of all pressure reducing and control valves, unless the branch feeding the valve is taken off the top the main and is less than 1.5 m in length.

All piping, fittings and flanges shall be cleaned and thoroughly degrease before assembly. The entire system must present a neat appearance for both workmanship and grouping.

3.11.2 Welding:

Welding shall be done by gas or electric arc process using equipment and plant laid down by BS 1821 and BS 2633.

The method of welding and testing shall be in accordance with the practice recommended by the BSI and AWS.

All operatives shall be thoroughly experienced and have certificate of competency. If necessary, these certificates shall be produced for scrutiny by the Engineer and welders shall be required to take such test as required by A.P.I.

Standard 1104 or as required by the Engineer. All welders shall be tested by M.E.W. Lloyd's Surveyor or equivalent. If necessary if there is bad workmanship in the opinion of the Engineer, the contractor shall be instructed to: -

a. Forthwith remove the operative responsible from the site.

b. Replace without charge all welding works carried out by the Operatives.

c. Meet fully all-financial claims made by the Purchaser occasioned by such replacement.

When welding is carried out, or a blowlamp used, adequate protection shall be given to prevent damage to any part of the building and the contractor shall be responsible for any such damage.

The outside diameter and the wall thickness of butt-weld fittings and welding neck flanges shall be the same as the outside diameter and wall thickness of the pipes to which they shall be welded.

Heat generated by welding shall not be allowed to accumulate at any bearing, bearing retainer, machined surface, or dis-similar metal components. Precautions shall be taken to dissipate the heat as it is generated.

The joints shall be tested to maximum tension required at the ambient temperature and pressure. The joints shall also be subject to a compression test up to a maximum deflection shown on the Data sheet, at service pressure and ambient temperature. At the completion of those tests, which are to be repeated in accordance with the required number of cycles, the joints are to be resubject to a hydrostatic pressure of 1.5 times the working pressure.

After completion of the above tests, the expansion joints shall be rejected if there are any leaks or sign of breakage of any point or part of the bellows.

15% of all welds shall be X-rayed. This identification number of the joints shall be stamped or painted on a metal sheet and fixed to the

expansion joint by wire. Both wire and metal sheets are to be corrosion proof.

3.11.3 Jointing:

Up to and including 50 mm bare pipe may be either welded or screwed for all cold services and hot services up to a working temperature of 85 Deg. C. The pipe shall be welded with flanged joints, above the size and where buried under ground welding shall be permitted with flanged joints.

The use of flanges shall be limited to the flanged connections to the valves, and equipment and the following:

Location of different access, and high and low points.

- Inspection holes.

On straight runs of pipe where frequent dis-assembly operations for cleaning and maintenance may be necessary. The interval between flanges should not normally exceed 15 m.

- Positions where equipment dis-assembly requires pipe removal. All bolts shall be of stainless steel as per BS requirements.

3.11.4 Supports and Hangers:

All pipe supports and hangers required for installation of the pipes shall be provided by the contractor. Vertical risers to be provided with suitable iron clamps. Brackets under the supports of pipes shall be provided with sheet metal cradles to spread the load. Pipe supports pattern to be approved by the Engineer and shall be "Roller type".

Protective covering shield shall be provided between all pipe supports, hangers and the insulated piping. Shield shall be made of a stout gauge galvanized mild steel of sufficient length to prevent depression of pipe covering.

Additional supports shall be provided and installed within 300 mm where pipes change direction and adjacent to flanged valves, strainers, equipment connections and heavy fittings.

All vertical pipe run shall be supported and laterally braced, at least once, at each building level.

Unless otherwise indicated on the drawings, vertical pipes shall be supported with riser clamps, installed below hubs, couplings or lugs welded to the pipe.

Hanger and supports shall be prepared and painted.

Insulated copper pipe shall be supported by copper supports or copper plated hangers.

3.11.5 Pipe Sleeves:

All pipes passing through walls, partitions and ceiling shall be provided with pipe sleeves. Sleeve size shall allow for the free movement of pipes. Sleeves passing through the finished service or exposed to view, shall be flush with the surface of the partition through which they pass, and shall be provided with suitable end covers of approved pattern and finish.

3.11.6 Expansion and Contraction of Pipes:

Shall be dealt with by compensators. In all locations where expansion is not taken by piping offsets, they shall have stainless steel or chromium melypelenum bellows and/or loop. Expansion more than 3/4", expansion bellows/loop shall be used. They shall have 3 rigid plot straps type guides with adequate bearing surface fixed at 4 times as the diameters on each end and suitable to prevent any axial movement. Anchors shall be provided between expansion units. These must be of sufficient strength to hold the mains tight against movement and withstand the thrust due to pressure and expansion but must not crush or injure pipe walls. The Contractor must consult the manufacturer for the precise position of the compensator and anchors and the amount of expansion that is to be taken by the compensators. The contractor shall make the calculations of expansion bellows, guides and anchors and obtain approval of the Engineer prior to commencement of the works.

3.11.7 Piping Specifications:

a Chilled Water Piping & Fittings ($2^1/_2$" inches and above):
Shall be black steel piping to ASTM Part 1, A 53-81 a steel pipes type S Grade B black finish, schedule 40 plain end finish. Fittings shall be standard weight type fittings to ASTM Part 1, A 234-81 a seamless wrought carbon steel grade WPI black finish or equivalent approved.

b.Chilled Water Piping (2" and below) City water, Make-up tank piping & Fitting:
Shall be of polybutylene. (Refer to Water Supply Specification).

c.Drainage Piping & Fittings:

Shall be high-density polyethylene (HDPE) pipes and fittings conforming to DIN 19535, DIN 8074 & DIN 8075 jointly.

3.11.8 Flanges:

Shall be provided on both sides of each piece of equipment in the plant, and where required, having diameter 2.5" and above shall be according to BS 10 or BS 4504 or equal approved.

3.11.9 Unions:

Shall be provided on both sides of each piece of equipment in the plant having diameter less than 2.5".

3.11.10 Dye-electric Joints:

Shall be provided for jointing two different pipe work materials or pipe work and equipments in order to isolate cathodically the pipeline or equipments. These connections shall be rated to withstand the maximum, medium temperature and pressure.

3.11.11 Vibration Eliminators:

Pipes connected to vibrating machinery shall be isolated from the supporting structure by vibration eliminators design for support by hanger rods. Pipes shall be isolated from the vibrating machinery by use of flexible metal pipeline connectors of metal or rubber flexible joint, to suit the fluids conveyed and the surrounding conditions.

3.11.12 Valves

All valves shall be factory fabricated and of types as shown on the drawings.

Valves shall be marked with name of manufacturer, trademark, nominal size and the class number, all cast in the valve body.

Valves, where possible, shall be of one manufacturer. Valves shall be designed for saturated steam working pressure of 861 Kpa (125 psi) and cold water non-shock working pressure of 1378 Kpa (200 psi) and shall be manufactured and factory tested in accordance with the latest relevant British Standard or an equivalent. Test Certificate shall be submitted for all valves.

Seating surfaces of valves shall be machined and finished to ensure tightness against leakage for the service specified and shall seat freely.

Hand wheels of valves shall be of suitable diameter to allow tight closure by hand with reasonable force without additional leverage and without damage to stem, seat or disc.

Valves located 2.4 m. or more above operating floor or platforms in plant rooms shall be provided with a chain operated hand wheel.

Flanged valves shall have flanges confirming to BS 4504-NP 16/11 or ANSI 125 or equivalent.

Cast iron body gate, globe and butterfly valves shall be provided with position indicator.

All cast iron valves shall be fitted with Cast Iron indexed hand wheel clearly marked "Open" and "Close" with an arrow to indicate the direction of rotation.

a. Gate Valves

Gate Valves shall be used for isolating purposes, as shown on the drawings.

Gate valves shall not be used for throttling purposes, such as regulating, balancing or controlling.

Gate valves shall be of double-faced solid wedge disc type giving straight-line flow.

Gate valves of sizes 2" mm and smaller shall be of all bronze construction type with inside screw non-rising spindle, screwed bonnet, and screwed ends to ASTM B-61, B-62 or of gunmetal to BS 1400/LG2.

Gate valves of size 2½" and larger shall be of flanged bonnet and flanged ends, outside screw rising spindle type. Body, wedge and cover shall be of cast iron, wedge facing rings and stem nut of gunmetal and spindle of aluminium bronze. Steam seal packing shall be of high quality suitable for Kuwait climate.

Gate valves of sizes 8" and larger shall be equipped with bevel gear unit.

b. Globe Valves

Globe valves shall be used for throttling purposes to control the flow rate from full flow to complete shut-off.

Globe valves of sizes 2" and smaller shall be of all bronze construction with inside screw rising spindle, screwed bonnet and screwed ends.

Globe valves of sizes 2½" and larger shall have cast iron body, with outside screw aluminium bronze rising spindle, renewable gunmetal or bronze disc, with gunmetal or bronze seat ring, flanged bonnet and

flanged ends. Globe valve disc shall be of the beveled or parabolic shape to allow throttling.

c. Check Valves

Check valves shall be silent, spring actuated lift type used to prevent automatically reversing of flow at pump outlets, in vertical lines and as indicated in the drawings or as required elsewhere.

Check valves of sizes 2" and smaller shall be of bronze construction, screwed ends.

Check valves of sizes 2½" and larger shall be of cast iron or ductile iron body, wafer type, stainless steel or bronze disc, stainless steel spring and renewable seats.

d. Butterfly Valves

Butterfly valves shall be used for shut-off or throttling purposes as shown on drawings.

Butterfly valves shall be of rubber/EPDM lined tight shut-off type, having ductile iron / ductile iron body, aluminium bronze disc, high grade stainless steel shaft, bronze bearings, monel metal taper pins, buna-n seat liner vulcanized to the body. The butterfly valves shall be wafer type or flanged type.

Butterfly valves of 4" and smaller shall have lever operator. Valves of 6" and larger shall have manual gear operator.

All butterfly valves shall be supplied with locking device and position indicator.

e. Commissioning Set

Commissioning set shall be provided on the return pipe of each water-cooling or heating coil and at other locations as shown on the drawings to facilitate balancing procedure. Commissioning set shall consist of a double regulating valve for flow regulation and isolation and metering orifice station for measuring the pressure drop.

The metering station shall have an integral square-edged orifice plate fitted with a pair of pressure test plugs, which can be connected to a manometer to measure the head loss. Bronze metering station shall have cast-in flow direction marking, and threaded ends. The cast iron metering station shall be supplied complete with two correctly sized gaskets and one set of flange bolting.

The double regulating valve shall be of the Y-pattern (Oblique) globe type having a parabolic disc for allowing regular variation of the valve opening. The variation of the opening is step controlled by a graduated adjustable sleeve fitted with the valve to control the lift of the disc.

Each opening position is indicated by a marked number on the sleeve. At any pre-set position, the valve opening can still be regulated from fully closed to a maximum opening at the pre-set position. The regulating sleeve is locked in the set position to prevent undesirable interference with the setting but remaining capable of being closed.

For size 2" and smaller Commissioning Set shall be of all bronze or gunmetal construction screwed ends and rising stem double regulating valve fitted with numeric indicator.

For sizes 2½" and larger Commissioning Set materials shall be as follows:

1) Metering Orifice Station
   Cast iron body, stainless steel orifice plate, gunmetal retaining bush and brass test plugs.
2) Double Regulating Valve
   Cast iron body, Stainless steel or bronze rising stem, gunmetal disc, gunmetal rings, anodized aluminium indicator plate and flanged ends.

Note:
No need for a separate metering Station if the DRV is provided with flow measuring provision.

DRV with pressure tapping for flow measurement will be considered for approval instead of independent Metering orifice Station.

Direct reading gauge with necessary hoses and other accessories shall be supplied in a portable sturdy metallic or plastic casing for each size of valve used.

3.11.13 Strainers:

Strainers shall be provided at the Suction side of each water-circulating pump and at other locations as shown on drawings.
Strainers shall be of Class 150 saturated steam-working pressure.

Strainers shall be Y-type.

Strainers shall be of same size as the connecting pipe.

Strainers for 2" pipe size and smaller shall be bronze body with stainless steel screen and screwed ends.

Strainers for 2½" pipe and larger shall be cast iron body with stainless steel screen and flanged ends.

Screen perforation shall be as follows:

Pipe size	Perforation size (mm)	Number of perforations per Sq. Cm.
UP TO 2"	0.8	64
2½" and larger	1.6	23

3.11.14 Automatic Air Vents:

Automatic Air Vents shall be provided at all high points of water piping system irrespective of whether indicated on drawings or not to permit venting any air collection at high points which tends to obstruct flow. Automatic air vents shall be of the float type, and construction shall be as follows: -

- Body and guide cross of bronze.
- Valve seat, guide bush, upper and lower guide connecting rod, valve and guide cone of brass or stainless steel.

Float ball of stainless steel.

All automatic air vents shall be installed with a suitable size shut off valve.

3.12 PACKAGED DIRECT EXPANSION UNIT

The unit shall be of internationally reputed and approved make and must have undisputed record of performance. The refrigerant used shall be 134A/410A.

Unit shall be factory assembled, precharged, prewired and tested.The contractor shall submit factory test certificates along with the submittal of the A/C Units.

Each unit shall consist of compressors, condenser, evaporator, expansion valve, filter drier, sight glass, interconnecting refrigerant, pipe work and all other standard accessories and controls. Each unit shall have two independent refrigerant circuits.

3.12.1 Casing:

The casing of A/C unit shall be of weather proof construction, suitable for outdoor installation, made of heavy gauge galvanized steel, baked enamel and suitable coat finish. Evaporator shall be of double skin construction. All panels shall be easily removable and all components must be easily accessible for servicing. Evaporator section shall have a suitable insulated drain pan and drain connections.

3.12.2 .Compressor:

Compressor shall be of thereciprocating/scroll/Screw type direct coupled to an electric motor and complete with vibration isolators and crank case oil heater.

Compressors 15 HP and below, can be of hermetic (sealed) type preferably with oil level sight glass.

Compressors above 15 HP shall be of Semi-hermetic (semi-sealed) multi cylinder type with service valves and oil level sight glass. All compressors above 15 HP shall have suitable capacity control arrangement.

For multi-compressor units, each compressor shall have its independentrefrigerant circuit.

3.12.3**.Condenser**:

Condenser coil shall be constructed of seamless copper tubes with aluminium plate fins mechanically bonded to the tubes. Spiral or round fins are not acceptable. Maximum number of fins not exceeds 14 per 25mm. Condenser coil (tubes & fins) shall be coated with special coating suitable to the working condition. See schedule of units for more details.

The condenser fan shall be propeller type with aluminium or steel blades direct driven, upward or sideward discharge, provided with protective screens mounted to the casing. Frame, blades, protective screens shall be coated with special coat suitable for the environment.

3.12.4**.Evaporator:**

Evaporator coil shall be of the same construction as of the condenser coil.

Evaporator coil face velocity shall not exceed 2.8m/sec.

Evaporator fan shall be of the forward curved design and sized to suit the system pressure.

Fan motors shall be installed on an adjustable base and secured by a locking device. Fan drive shall be through adjustable pitch pulley. Fan drive shall be provided with sealed, permanently lubricated ball or sleeve bearings and the entire fan assembly shall be statically and dynamically balanced.

3.12.5**.Motor Enclosure and Insulation**:

The following are the minimum requirements of enclosure and insulation for motors:

Type of Motor	Enclosure	Insulation
Compressor Motor	Hermetic/Semi-Hermetic	Special
Condenser Fan Motor	TEAO	Class 'F'
Evaporator Fan Motor	TEAO	

	IP55 Protection	Class 'F'

3.12.6.**Control Wiring & Protection Devices**:

The thermostat control voltage shall be 24 volts. The A/C units being offered must feature the following minimum requirements of safety interlocking and protective devices.

a) Safety electrical and mechanical interlocking of evaporator fan motor withcompressor/heater operation and interlocking through an airflow switch, wherever duct heaters are provided.

b) Where multiple compressors are incorporated in the units, their operation must be in sequence in accordance with return air temperature.

c) Manually reset and adjustable oil pressure differential cutout of 90-sec/120sec. trip time rating for compressors of 25 HP and above.

d) Manually reset and adjustable high pressure and adjustable automatic low-pressure cutout for compressor protection.

e) Time guard circuit for preventing compressor rapid recycling preferably of adjustable range from 5 minutes to 15 minutes.

f) Time delay relay for sequences starting of multiple compressors system of minimum 15-sec. delay rating.

g) Separate single phasing preventor suitable for three phase, 415 volts, 50 Hz. Power supply to prevent the whole unit from single phasing phase shift and under voltage with a response time rating of maximum 2.0 sec.

h) Inherent thermal protection for compressor motor winding, three phase evaporator fan and condenser fan, motor windings.

i) Inherent thermal protection or manually reset thermal or magnetic overloads for single phase condenser and evaporator fan motors.

j) External thermal overload with manual reset or MCCB of suitable rating for all three phase motors in addition to (h) above.

k) The unit shall be controlled by a room thermostat housed in a suitable perforated transparent casing with a lock. Control voltage of the circuit to which thermostat is connected shall be 24 V . Automatic reset with lockout relay shall be acceptable in lieu of manual reset controls.

l) The control panel shall be IP 54 at least.

3.12.7.**Returns Air Filter Plenum**:

Return air plenum shall be an integral part of the unit, factory assembled. Plenum shall be suitable for accommodating 50mm thick metallic cleanable filters with a face velocity not exceeding 1.8 m/sec. However equal and approved field installed filter plenums are also acceptable.

3.12.8**.Return Air and Fresh Air Filters**:

a) Return air filters shall be permanent and washable type made of aluminium or G.I. sheet designed for heavy duty and shall be sized for maximum air velocity of 350 ft. per minute with initial pressure drop of not more than 0.25 inch W.G. at the rated air flow. Filter media shall consist of cripped G.I. or aluminium arranged to give maximum area for airflow.

b) Return air filters shall be enclosed in a separate filter frame integral unit.

c) Fresh air filters shall be of the same specification as return air filters.

d) Thickness of return air filters shall be 2” and that of fresh air filters shall be of 4”.

3.12.9**.Thermostat**:

Each unit shall be controlled by two stages room thermostat mounted inside the room. The control voltage shall be 24V. Protective perforated metallic box with lock and key shall be provided for each thermostat.

3.13 **MINI SPLIT A/C UNIT:**

Mini Split A/C unit shall consist of an air-cooled condensing unit and a matching fan coil unit, factor assembly, pre-wired, precharged and factory tested. The refrigerant shall be 134A or 410A.

3.13.1 **Condensing unit**:

a) **Casing**

Casing shall be constructed by heavy gauge M.S sheet metal and shall be firm and rigid.

Casing shall have an approved anti-corrosive and heat resistant paint finish.

b) **Coil:**

Condenser coil shall be made of seamless copper tube with copper straight fins, mechanically expanded over the tubes.

c) **Compressor:**

Compressor shall be made of hermetic reciprocating or rotary type of appropriate capacity and shall be suitable operation on 415 V, three phase, 50 Hz. or 240 V, single phase, 50 Hz, supply with permissible voltage variation of

+/- 6%. Compressor shall have inherent thermal protection or external thermal overloads.

d) **Condenser Fans:**

Condenser fans shall be multi-blade type directly mounted on drip proof motor with Class "A" insulation and shall be suitable for operation on 415V, three phase, 50 Hz or 240 V, single phase, 50 Hz supply with permissible voltage variation of +/- 6%. Condenser fan motors shall be provided with inherent thermal protection.

3.13.2. **Fan Coil Unit**:

Fan coil Unit shall be wall mounted / ceiling suspended type.

a) **Casing**:

Casing shall be heavy gauge M.S. sheet, with decorative type stove enamel finish, and shall be adjustable type air deflector.

b) **Evaporator**:

Evaporator coil shall be made of seamless copper tubes with aluminium or copper fins mechanically bonded to the tubes. Spiral fins are not acceptable.

c) **Fan**:

Fan shall be multi-blade centrifugal, two or three speed impeller type directly mounted on motor shaft and shall be easily accessible for maintenance. Fan motor shall be open type with Class "A" insulation, provided with inherent thermal protection and suitable for 240 V, 50 Hz, single phase power supply.

d) **Air Filters:**

Air filters shall be of permanent cleanable and washable type and shall be easily accessible, thickness shall be minimum 12.5 mm.

3.13.4..**Other Requirements**:

a) Pre-charged and pre-insulated refrigerant tubing as supplied by manufacturer of the A/C unit shall be used. The insulation shall be wrapped with 8-oz canvas and painted with two coats of weatherproof paint.

b) Drain pipe sizes shall be minimum 19-mm diameter and the material shall be GI. The drain pipe shall be connected to the drain point of the unit with transparent plastic flexible hose and jubilee clips.

c) A remote control switch and thermostat shall be provided for the unit.

d) All mountings, brackets, bolts, fixtures, etc. for installing the condensing unit and fan coil unit shall be provided.

e) Each outdoor unit shall be provided with built in isolator for isolating the Unit. All mini-split A/C units shall be provided with proper earthing as per MEW's specification.

3.14 Duct Works

All ducting shall be made of galvanized steel sheet to ASTM A525, lock-forming quality, having zinc coating of 275gm/M² for both sides in accordance with ASTM A90 and of tensile strength 28/33 tons per square inch.

All ducting shall be made as indicated in the installation drawings and successful tenderer shall check the installation and building before hand and ensure that the existing structures, etc., shall not come in the way of ducting at time of installation. Dimensions of ducting can be altered by the contractor with the prior approval of concerned Engineer without altering permissible airflow rates.

All ducting shall be suitably stiffened to avoid vibration, sagging and running effects due to airflow. All ducting shall be made airtight.

3.14.1 **Gauges** of G.I sheeting, type of joints, bracing, … etc., used for the manufacture ducting shall be as shown below: -

The throat radius of bend shall not exceed half the width of associated side of the duct and where it is not possible to comply with this duct turning vane shall be used along with the right angle bends. The duct turning vanes shall be spaced in such a way that the speed ratio of each of the individual elbows shall be around 6:1.

Maximum Side inches	US Standard Gauge	Transverse Joints and Bracing
Up to 12"	24	¾" pocket or slip joint at 8 ft. centres.
13 – 18"	24	1" pocket joint at 4 Ft. centers with cross breaking.
19 – 30"	22	1" pocket joint at 4 Ft. centers with cross breaking.
31 - 42"	22	1½" pocket joint at 4 Ft. centers with cross breaking and ½ x ½ x 1/8 angle with girth at 8 ft. centres bolted to the pocket joint.
43 – 54"	20	1½" pocket joint at 4 Ft. centers with cross

		breaking and 1½ x 1½ x 3/16 angle with girth at 8 ft. centres bolted to the pocket joints.
55 – 72”	20	1½” pocket joint at 4 Ft. centers with cross breaking and 1½ x 1½ x 3/16 angle with girth at 4 ft. centres bolted to the pocket joints.
73 Up to	18	2½” x 1½” x 3/16 angles at 4 Ft. centers bolted to the duct with 3/8 bolts at 1½ centers and fastened together with 3/8” bolts at 2 centres with rubber gasket between the 2 angles and cross breaking.

3.14.2 **Joints:**

- 50 mm Slip Joint or Draw Band is acceptable through 1500-mm size.

-Slip or Draw Band Joint.

-Flanged Joint.

-All tees, Bends and Elbows shall be constructed with radius of not less than 1½ times diameter of duct on centerline. Where not possible and where rectangular elbows are used, aerofoil-turning vanes shall be provided.

Transformation of duct sizes shall be gradual, not exceeding 15 degrees divergence and 30 degrees convergence.

Round duct fittings shall be of welded type construction. For ducts of diameter up to and including 300-mm. diameter, one-piece smooth 90 deg. elbows shall be used. Over 300-mm dia. they shall be 5 piece welded.

3.14.3. Turning Vanes

Shall be fabricated in accordance with SMACNA Standards.
Turning vanes shall be as follows:

- Factory or site-fabricated using factory-fabricated vane spacing rails.
- Turning vanes shall be provided in all square elbows, take-off or extension collars to supply outlets and tap-in branch take-off connections.
- Turning vanes shall be reinforced by rods or of sectional construction.

- Turning vane arrangements and thickness shall be as shown in the following table:

Type	SINGLE VANE	SCHEDULE
	Space between Vanes	Radius	Gauge
Small	1½"	2"	24
Large	3"	4½"	22

3.14.4 Volume Control Damper:

Volume control dampers shall be provided in ductwork to regulate and balance air systems, since dampers on the air inlet and outlet shall be used only for fine secondary regulating or balancing. The damper shall be fabricated in accordance with SMACNA Duct Construction Standards.

Single blade dampers shall be used for damper widths up to 300 mm. provided that there is sufficient length of straight duct after the damper to ensure equal flow before the next take-off or outlet. Where the damper width is over 300 mm. multi -blade dampers shall be used. Multi blade dampers styles shall be generally parallel blade for two-position operation and opposed blades for modulating position. The blades shall be constructed of galvanized sheet, suitably stiffened by forming or other method, and assembled in prime coated or galvanized channel frame with suitable hardware. The bearings shall be of bronze or oil impregnated nylon.

Looking and indicating quadrant regulator shall be provided for each damper. The indicating quadrant shall be clearly marked to indicate close, 1/4, 1/2, 3/4 and open positions. On insulated ducts, quadrant regulators shall be mounted on stand off mounting brackets or bases.

For motor operated damper, the motor-operator shall be electric type.

3.14.5 Fire Dampers:

Shall be fabricated in accordance with NFPA 90A and UL 555 or equivalent and shall be as follows: -

- To be provided in ducts and openings in shafts, floor, firewalls, fire partitions and the rated ceilings.

- In horizontal ducts, fire dampers may be single or of a multi blade type. In vertical ducts only single blade type shall be used.

- Galvanized sheet metal housing to be provided with angle flanges on both sides.

- The damper shall be of 1.6 mm thick sheet steel or steel/mineral fiber/steel sandwich of equivalent fire resistance, thermally released.

- Fire dampers shall be equipped with fuse plug, positioning levers, fittings and position indicator accessible from outside.

3.14.6 Grilles and Registers:

They shall be furnished with sponge rubber gaskets or foam tape behind the frame to eliminate air leakage and with nylon bushings or PVC at the blades connection to the frame to eliminate corrosion and vibration. Free cross-sectional area shall be at least 65 percent.
Supply air registers and grilles shall have individually adjustable horizontal front blades and vertical rear blades.

Supply air register shall be equipped with key operated, opposed blade volume control damper.

Return and exhaust air registers and grilles shall have fixed single deflection blades set at an angle of 35 degrees.

Return and exhaust air registers shall be equipped with key operated, opposed blade volume control damper.

All opposed blade volume control dampers shall be polyester powder coated ovens taken with black colour finish.

3.14.7 Ceiling Air Diffusers: -

Same materials as the Grilles and Registers, to comply with capacity, throw, noise level requirements, and static pressure drop. 1, 2, 3 & 4 way airflow patterns square ceiling diffusers suitable for each location, colour selected by the engineer to match the architectural finishes.

3.14.8 Access Doors

Air tight access doors with rubber linings shall be installed in all ducts at fans, filters, heaters, fire dampers and volume dampers for inspection, cleaning and maintenance purposes.

The opening in the ductwork shall be properly stiffened at the edges, with frames riveted or welded to the duct. The access door shall be as follows:

All Access Doors mounted on insulated ducts shall be of sandwich type, having the same insulation thickness as that of the duct, with Cam Lock handles.

Maximum Size(mm)	No. of Hinges	No. of Handles	Gauge of Door Panel	Frame
12" x 12"	2	1	24	24
16" x 20"	2	2	22	22
24" x 24"	3	2	22	22

3.14.9 Flexible Connections

Flexible connections shall be fitted on all suction and discharge connections of fans and air conditioning units, for preventing transmission of vibration through the ducts to occupied spaces.

Flexible connections shall be made from flame proof, factory fabricated from chemically impregnated canvas. Connections shall fit closely and be secured in an airtight fashion to duct work, fans and apparatus by means of angle iron or flat iron frames. The unclamped section of the flexible connection between the apparatus and the ductwork shall be not less than 150 mm. in length. Flexible connections shall not be painted.

3.14.10 Supports and Hangers

Installation of supports and hangers shall be as follows:

- Supports and hangers shall be attached only to structural framing members and concrete slabs. They shall not be anchored to metal decking unless a means is provided and approved for preventing the anchor from puncturing the metal decking.
- Supports shall generally be made from galvanized steel sections, and where heavy items of equipment occur within ductwork additional support shall be provided as necessary.
- Duct work hung from inserts or from clip angles shall be secured with expansion bolts in shear.
- Supports for horizontal ducts shall be as follows:

RECTANGULAR DUCT

Length of Longer Side (mm)	Drop Rod Diameter (mm)	Bearing Member (mm)	Maximum Spacing (inch)
Up to 12"	8	20 x 3 Flat	60"
Over 12" Up to 4"	8	25 x 25 x 3 angle	60"
Over 24" Up to 40"	10	40 x 40 x 4 angle	60"
Over 45"	10	50 x 50 x 5 angle	60"

Up to 64”			
Over 64”	15	75 x 75 x 6 angle	60”

-Design of supports for vertical ducts will be dictated by site conditions and spacing may be greater than for horizontal ducts.

- Supports for vertical ducts shall be angles and channels made of galvanized or painted black steel.

  Vertical duct shall be fastened with a minimum of 2 supports at each floor.

3. 15. Thermal Insulation and Lagging

Requirements:

Thermal insulation shall be of approved material with thermal conductivity not higher than 0.29 Btu/Hr/Ft2/F inch thickness measured at an average temperature of 100 F. Thermal insulation shall be non-corrosive to the metal, water repellent, sustenance to vermin and easily cut and fitted to shape during application. The insulation should be resilient and retain its original shape. The insulation shall be provided with approved fire retardant vapour barrier jacket to prevent the moisture penetration to the insulation. Vapour barrier shall also be applied to all joints and edges.

The insulation shall be fixed on to the metal surface by means of an approved adhesive compound that has no corrosive effect on the metal and thoroughly applied to the metal surface and insulation. The insulation shall be carried out by skilled labourers and before thermal insulation is applied, all metal surfaces shall be thoroughly cleaned and treated with approved corrosion inhibitors.

3.15.1. Piping Insulation:

The insulation shall be secured to the piping by adequate number of non-corrodable straps ¾” width at a center distance not more than one feet.

The straps shall not in any case cut the insulation or the vapour seal. Wires shall not be acceptable.

Insulation Material Thickness

Insulation material shall be Fiberglass 6 lb/Ft³ & shall have the following thickness.

Service	Pipe Size		
	Up to 2" dia.	2½" – 6" dia	8" dia and above
Chilled / Hot Water Pipes Exposed to Sun	1"	2"	3"
Chilled/Hot Water Pipes in non-A/C areas.	1"	1½"	2"
Chilled / Hot water pipes in A/C areas	3/8"	1"	1½"
Condenser Water (Cold) pipe from cooling tower to condenser exposed to sun.	1"	1"	1"
5. Condensate drain pipe	3/8"	5/8"	--

All pipes running inside the A/C Plant room, A/H unit rooms and other machinery rooms also inside the piping shaft or were they are exposed to view shall be covered with heavy gauge "not less than 22" aluminium sheet, and in any case the designation and direction of fluid flow shall be suitable marked on the surface at intervals. Weather and water proofing treatment to be carried out prior to cladding.

3.15.2 Duct Work Insulation:

a. The thermal insulation used shall confirm to BS 5422: 1977.

The thermal insulation shall be made of fiberglass material with reinforced aluminium foil external coating, factory applied with resin bonded internal layer to give flat and resilient surface. The insulation of all duct works exposed to outside and those in plant rooms shall be rigid slab type and for remaining ducting flexible blanket type.

Thermal conductivity shall not be more than 0.29 Btu/Hr. Sq. Ft. per inch thickness measured at an average temperature at 100° F. The thermal insulation shall be non-corrosive.

The insulation shall be provided with fiber retardant, vapour barrier jacket to prevent moisture and penetration. Vapour barrier shall also be applied to all joints and edges.

The insulation shall be applied to metal surface by means of approved non-corrosive adhesive compound.

The metal surface shall be treated with corrosion inhibitors before the application of insulation.

The density of insulation shall be minimum 1.5 lb./cu. ft. for flexible blanket type and 3 lb./cu. ft. for rigid slab type and thickness as below: -

All duct works exposed outside and those in plant room shall be insulated with 2" outside insulation.

Duct works inside air-conditioned spaced shall be insulated with one inch thick outside insulation.

Insulation shall be secured to duct work with 2" x 2" G.I. sheet metal strips of 22 gauge fixed to corners and tightened with wire 6" intervals. The strips may be suitably grooved to take the wire fasteners.

In addition, all duct works exposed to outside be cladded with 24 gauge GI sheeting and shall be treated for water proofing prior to cladding, i.e. wrap the insulation with 0.5mm thick polyethylene sheet and secure the adhesive. All the duct works in plant room shall be finished with 8 Oz. Canvas with 2 coats of fire retardant and water proof paint.

All external duct cladding shall be painted with one coat of primer suitable for galvanized surface and two coats of final paint suitable for external application.

Colour of paint should match the building and approved by the Engineer.

3.15.3 Acoustic Duct Lining

Internal duct lining for acoustic insulation where applicable shall not be less than 25 mm. thick fiberglass mat faced, flexible blanket of fine fibers with securely bonded surface mat coated with black neoprene or approved equal. Lining shall be applied with 100% coverage of fire resistive approved adhesive compound and mechanical fastenings according to the manufacturer's instructions. Acoustic lining shall be cleared 20 cm. on each side of the duct heater where applicable. Duct lining density shall be 24 kg/cubic meter.

3.16 **INSTRUMENTS**

3.16.0 General

All instruments described hereunder shall be provided and installed as applicable.

All equipment such as water chillers, condensers, boilers, air handling units, cooling and heating coils shall be provided at the water inlet and

outlet sides with pipe mounted oil-filled pockets for thermometers and cocked connection with pressure gauges to suit. These fittings must be provided whether a gauge is required at that particular point or not.

All instruments shall be installed in such a manner and at such locations as to sense accurate representative values of the function that they measure and to be accessible for ease of adjustment and calibration.

Indicating instruments, such as thermometers and pressure gauges installed on insulated pipes shall have proper length extension necks to extend the instrument to the final finished surface of insulation.

Indicating instruments, such as thermometers and pressure gauges installed on insulated pipes shall have proper length extension necks to extend the instrument to the final finished surface of insulation.

Indicating instruments shall have a range such that the normal readings are indicated in the middle of the range of instrument.

3.16.1 Pressure Gauges:

It shall be at least 150-mm. nominal diameter and shall confirm in all relevant requirements to the class 1 industrial concentric scale gauge as specified in BS 1780 Part 2. The dial shall be provided with a stop in the zero position.

The total scale be so chosen from BS 1780 part 2 that the operating pressure is between 40% and 75% of the scale range, each dial shall have the following information marked upon it.

a. Operating pressure in red
b. Maximum permissible working pressure in purple.

All pressure gauges shall be fitted with a siphon pipe and a cock adjacent to the gauges in such a manner that the gauge may be shut off and removed while the line is under pressure. Where a cock is fitted, the handle shall be parallel to the bore of the cock when the cock is open.

The cock shall have a connection for the attachment of a test pressure gauge, this connection shall be tapped ⅜" and shall be fitted with an easily removable plug.

The pressure gauges shall have dual calibration both in PSI and Kg./cm².

The pressure gauges shall be supplied and installed at the following locations.

Service	Location

Water pressure	Chilled water pumps Supply and discharge
Water pressure	Chiller inlet and outlet
Water Pressure	A/H Unit inlet and outlet
Gas pressure	Compressor suction and discharge

Phosphor Bronze / Stainless steel Bourdon tube type, 5% accuracy, bottom connection.

3.16.2 Thermometers

Thermometers shall be furnished complete with all necessary sockets, wells connectors and accessories required for complete installation and suitable for the service in which installed. Extension necks shall be furnished for insulated piping and ductwork.

Where installation necessitates that a thermometer be installed at a height exceeding seven feet above the floor, or at a location not easily accessible or visible, a remote bulb type thermometer shall be installed and identified at a location as directed by the Engineer.

Glass Thermometers

Glass thermometers shall be of materials and ranges, as indicated, designed and constructed for use in service.

CASE: Dye-cast aluminium finished in baked epoxy enamel, glass front, spring secured, 225 mm. long.

TUBE AND CAPILLARY: Mercury filled, magnifying lens, 1% scale range accuracy, shock mounted.

SCALE: Satin faced, non-reflective aluminium and with permanently etched markings.

STEM : Copper plated steel, or brass, for separable socket, length to suit installation.

Service LocationRange

Water Temperature	Each A/H Unit inlet & outlet	32-100° F
Water Temperature	Each evaporator inlet	20-140° F
Water Temperature	Each evaporator outlet	20-140° F

The thermometers shall have dual calibration both in °C & °F.

3.17 **Chilled Water Thermal Storage Tank (If applicable)**

The contractor shall be responsbile for design, supply and installation of chilled water thermal storage tank. The design shall be done by an MEW approved consulting office and submitted to MEW for approval

prior to ordering the termal storage tank. The design shall be based on the following standards and codes: -

a) ASHRAE 2008 Systems and Equipment Chapter 50.

b) ANSI/ASHRAE Design Guide for Cool Thermal Storage.

c) ASHRAE Standard 150 - Method of Testing the Performance of Cool Storage Systems.

d) AWWA – American Water Works Association D 100-05 Welded Steel Tanks for Water Storage and D 102-06 Painting steel water Storage Tanks.

e) ASME B31.1 – Code for Pressure Piping-Power Piping.

f) NFPA – National Fire Protection Association Standard for Private Water Protection.

g) API-American Petroleum Institute Standard 650 – Welded Steel Tanks for Oil Storage.

3.18. Details of Tests on Completion

The Contractor shall notify the Engineer when he wants to proceed with tests on completion. All the equipment, instruments and labour necessary to perform the test shall be furnished by the contractor. All tests shall be made to the satisfaction of the Engineer and shall be approved by him.

3.18.1. The following test shall take place:

Upon completion of the installation, but before insulation and covering are applied all piping shall be pressure tested and proved absolutely tight. Piping shall be tested in accordance with the American Standard Codes for Pressure piping by maintaining the required pressure during the test.

System Tested Where applicable	Test pressure	Duration of Test	Fluid
Chilled Water piping	225 PSIG	6 Hours	Water

Any leakage or faults discovered during such tests shall be remedied at once by the contractor at his own expense and the tests shall be repeated until the engineer is satisfied that the section under tests is sound and the Engineer's decision whether the test is sound or not shall be final.

After each test signed Certificate of approval shall be obtained from the engineer.

3.18.2. Equipment Inspection

- Air-Cooled Chillers, Air-Handling Units: To be tested according to ARI Standards.
- Electrical Motors: Speed-rpm, amperes on each phase and power input in kW for each motor.

3.19. **Guarantee Maintenance Period:**

Guarantee maintenance period shall be for a period of One-year commencing from the date as recorded on the Acceptance and Taking Over Certificate, for each type of equipment. On completion of the guarantee period to the satisfaction of the M.E.W Engineers, a final completion Certificate shall be issued to the contractor.

3.20. **Working Drawing & Instructions:**

The contractor shall submit to the engineer, for approval within 8 weeks of awarding the contract all the working drawings, patterns, models, samples, catalogues required for the erection.

All working drawings required should be submitted in one lot, part submission will not be considered.

3.21. **Installation Inspection**:

On completion of all installation in accordance with the specifications and drawings, an installation inspection will be carried. On satisfactory completion of the installation inspection, Erection and Handing over Certificate will be issued.

3.22. **Initial Trial Tests:**

After the completion of the works, the contractor shall and as directed by the Engineer, demonstrate to the Engineer that the installation is adjusted and regulated correctly to fulfill the function for which it has been designed. Contractor shall test, adjust, balance and regulate the section concerned as necessary until the required conditions are obtained. Include for continuity and insulation test all interlocks, safety outlets and other protective devices to ensure correct functioning. All such tests shall be carried out in the presence of the Engineer and full records of values obtained shall be prepared along with the final settings.

3.23. **Reliability test**:

After finishing the initial trial test to the satisfaction of the Engineer, the contractor shall be responsible for running reliability test for all plants and equipment.

The reliability tests shall be under the full responsibility of the contractor and he shall provide full time skilled operators for running the plants during the whole test period.

Each reliability test shall last for a period of 31 (thirty-one) consecutive days during which time the whole of the plant under test shall operate continuously without adjustment or repair, to the satisfaction of the Engineer. In the event of any repair or adjustment, the test shall be void and the installation shall be readjusted. The test shall not be void due to repairs outside the control of the contractor.

The whole reliability test of the refrigeration and cooling plants shall take place during the period between 20th of May and 15th Sept. For heating equipment shall be during the winter season (1st Dec. to 15th February). On satisfactory completion of the reliability tests, "Taking over and Acceptance certificate" will be issued.

3.24. **As Fitted Drawings and catalogues**:

The contractor shall supply 3 (three) sets of "As fitted" electrical, civil and mechanical drawings, installation instructions, service manuals and spare parts catalogues for each and every equipment installed prior to the installation inspection.

3.25. **Micro-Film and CD**:

Contractor is required to supply 2 sets of standard 35mm micro film aperture cards photographed from "As fitted" drawings.

Full particulars of the drawings to be furnished on the reverse side of the card, including reduction ratio. The front face of the card must be left blank for Ministry's Drawing Office use.

A sample of processed microfilm aperture card to be submitted to the Ministry for approval.

Drawings on compact discs (3 Nos.) shall be supplied in addition to microfilm.

SECTION 4G.2

WATER SUPPLY

CONTENTS

SECTION 4G.2

WATER SUPPLY

1. GENERAL

This section describe the specification for potable water supply, the whole installation shall be carried out in accordance with BSS CP310 or the equivalent International Standards where these apply, or the local water Authority Regulations.

2. SCOPE OF WORK

The water shall be supplied from the city main potable water line to the high storage tank, from where water is supplied by gravity / booster set to the network. The scope of works shall include but not limited to the following: -

2.1 Supply and installation of piping, valves, fitting, etc. as per BOQ and as per drawing. All piping shall be concealed.

2.2 Supply and installation of the following per BOQ.

a) Potable water booster set

b) Central water heaters and unit water heaters.

c) Drinking water filter for each kitchen (British Berkefeld or equal approved) .

d) Central water filter.

e) Water coolers as per specifications one for each kitchen.

f) GRP tanks as given in BOQ and shown in drawings.

g) Required and necessary piping, fittings and valves

3. TYPES OF PIPES:

All underground pipes and fittings 80 mm and above shall be ductile pipes and fittings to ISO – 2531. All underground pipes and fittings below 80 mm shall be of HDPE confirming to DIN 8074 and 8075 jointly. All other pipes used for conveying hot and cold water shall be Polybutylene pipes and fittings complying in all respects with BS EN ISO 15876(DIN 16831, 16968 &1696) with pressure classification of PN 20. Approved manufacturer – George Fischer or equal approved.

4 PIPING INSTALLATION:

General piping requirements shall be in accordance with the following and manufacturer's recommendations.

4.1 Piping shall be kept free from scale and dirt. Pipes shall not be split, bent, flattened nor otherwise injured either before or during the installations. No bends or curve shall be made in any pipe, which will diminish the waterway or alter the internal diameter of the pipe in any part.

4.2 All cutting shall be square to the pipe axis by approved means and all burs removed. The use of pipe cutting machine that diminishes the bore of the pipe shall not be permitted.

4.3 All pipes shall be free from cuts, dents or other surface damage. At the time of final inspection, damaged pipe shall be removed and replaced with new pipe.

4.4 Where practicable, pipe work shall be carried out, as the building proceeds, so as to minimize the amount of cutting away and repairing.

4.5 Generally, all internal work shall be concealed in ducts or chases in concrete, brick or blockwalls, unless otherwise shown or specified in the drawings but subject to the approval of the Engineer.

4.6 The contractor is responsible for the correct marking out of the position, of all necessary holes in walls, floors, ceilings, etc., for pipes and pipe supports. No pipe or other apparatus shall be installed in such a way as to interfere in any way with the swing of the doors.

4.7 The run and arrangement of all pipes shall be as shown on the drawings and as directed during the installation. They shall be as straight and direct as possible, but forming right angles or parallel lines with building walls and other pipes and be neatly spaced.

4.8 Clearance between exposed pipes and the finished surface of wall, partition or ceilings, shall be not less than 50 mm.

4.9 Swing joints, offsets, expansion joints, etc., shall be provided wherever and/or necessary to accommodate expansion of piping.

4.10 Where pipe size shown or specified differ from the connection size or fixtures, outlets, etc., reducing fittings shall be installed. Bushing shall not be allowed unless specifically approved.

4.11 Unions or flanges shall be provided at all by-pass tanks, heaters and elsewhere as may be required.

4.12 All horizontal runs of piping except where concealed in partitions or false ceilings shall be kept as high up as possible and close to walls, with a minimum clearance of 45 cm.

4.13 The embedding of valves, stop-cocks, unions or other removable fittings into concrete, plaster or other material, so that they cannot be repaired or replaced without cutting the surrounding material will not be permitted.

4.14 All ends of pipes shall be temporarily plugged to prevent dirt accumulating or stoppage of the pipes to fixtures by an approved plug. Paper, wood, rags, etc., shall not be used.

4.15 Provision for expansion of pipes shall be done as per Manufacturer's recommendations.

4.16 Hot water pipes shall be insulated with ½" thick HT Armaflex or equivalent insulation. Insulated pipes in Mechanical rooms and exposed to view shall be cladded with 0.6mm aluminum cladding.

4.17 Water Supply piping shall, without restricting the general piping requirements of the foregoing, be installed as follows: -

i) Water supply piping shall be complete from service connection to all fixtures, equipment, outlets etc., sizes of pipes shall be as shown and or specified. No pipe size allowing over 5 ft. per second velocity in the water supply piping has been specified nor will be permitted.

ii) Schedule of pipe size for water supply connections at fixtures shall be as follows:

Fixtures:	Size (inch):
Water closet (flushing tanks)	½"
Hand wash basins	½"
Sink	½"
Urinals	½"
Dish Washer / Washing machine	½"

5. VALVES:

The contractor shall furnish and install all valves shown on the drawings and as instructed for the proper control of piping and equipment. All valves shall be resistant to disincification.

Gate valves 2.5" and smaller in size shall be Bronze in accordance with BS 5154 Series A.

The valve shall be of solid or flexible wedge type and shall have rough bodies and finish trimmings.

5.1 Globe Valves:

Globe valves 2.5" and smaller in size shall be bronze in accordance with BS 5154 Series A. The valves shall have rough bodies and finished trimmings, except that those in chromium plated pipes shall be finished and chromium plated. Disc shall be of a composition suitable for the service. Valve ends for threaded pipes shall be screwed.

5.2 **Check Valves**:

Check valves 2.5" and smaller in size shall be bronze in accordance with BS 5154 Series A. The valves shall have rough bodies and finished trimmings and unless otherwise specified, shall be of the swing coach type with composition brass discs. Valve ends for threaded pipe shall be screwed.

5.3 **Bib cocks**:

Bib cocks shall be all bronze construction and chromium plated and shall be installed to isolate each fixture.

Gate valves shall be provided to isolate complete toilet or kitchen areas. One valve shall isolate the hot water service and one the cold water service. These valves shall have extended spindles, threaded pipe connections, loose key head part and sliding flange.

6. **TYPE OF FIXING:**

6.1 **Escutcheons**

Where uninsulated exposed pipes pass through floors, finished ceilings, they shall be fitted with neat, heavy spun, cast or chromium plated stamped brass sheet escutcheons firmly secured to the pipes. The escutcheons shall be of sufficient outside diameter to amply cover up the sleeved opening for the pipes. Where escutcheons are not furnished with plumbing fixtures, they shall be supplied under this section.

6.2 **Flashing**

Pipes extending through roof shall be flashed with sheet lead, copper or other durable material to make the roof watertight.

Complete shop drawings showing method of dressing as may be required by the Engineer shall be submitted for his approval prior to the installation.

7. **DRINKING WATER COOLER** :

Drinking Water cooler shall be of type 'B' have an output of 12 GPH when handling water at an inlet temperature of 100° F and in a room temperature of 115° F with storage capacity of 12 gallons and shall be according to MEW Standard Specifications for water coolers. The cooling coil shall be outside the tank and shall not come in to direct contact with water. The filter shall be CUNO USA or equal approved.

8.**ELECTRICAL WATER HEATER**:

The electric storage type water heater shall be vented and open to atmosphere or pressurized type. The storage capacity shall be as mentioned in B.O.Q.

The design of the heater shall be in accordance with the MEW General Specifications for Electrical Installations MEW/S-1.

9. **WATER METERS:**

Water meters shall be of the type approved by the MEW and be suitable for use with both potable and brackish water.

They shall be of a positive displacement helix type suitable for mounting in a horizontal pipeline.

Head loss through the meter shall be negligible as water passes through the meter without restriction or change of direction.

10. **GRP WATER TANKS**:

10.1. **General:**

The manufacture and installation of Hot Press Moulded GRP Sectional Water Storage Tanks shall conform to BS 5750: Part 2: 1987/ISO 9002/EN29002 and shall be covered by a Certificate of Conformity stating the manufacturer's approval number and name of the approved body.

10.2 **Manufacture**:

Tanks shall be hot press moulded, glass reinforced plastic, moulded at a closely controlled temperature of 140ºC.

The material shall be medium pale blue/grey colour and shall include a minimum 30% glass content, Isophthalic Polyester resin throughout and U.V. Stabilizer conforming to BS 5734: Part 5: 1980.

The tank design shall incorporate truncated pyramid shape meter square or meter by half-metre panels and corner angles manufactured to a tolerance of +/-0.5 mm.

All surfaces of the panels shall be smooth and crevice free to provide hygienic finish. Flanges shall be factory drilled.

Heavy-duty covers shall be self-draining type, complete with 850 mm square bolted access door, air vent with insect screen not exceeding 0.65 mm aperture, but with an open area of 37%.

All tanks deeper than 1.5m shall be fitted with internal GRP and external aluminium access ladders. Access ladders shall generally be to the requirements of BS 4211.

Where a tank is devided into two compartments, a full height partition made from standard panel shall be provided and be capable of working normally

with one side emply. Each compartment to have provision for access doors and air vents as detailed above.

10.3 **Bracing**:

The tank shall be braced by a combination of external galvanized RHS supports and internal 304 quality stainless steel tie rods.

The tie rods shall be attached to the vertical RHS supports to provide continuous bracing to the flanges of the tank panels and have a means of pre-tensioning that eliminates point loads.

10.4 **Base Supports**:

Tanks shall be installed on flat screeded bases or on steel beams conforming to manufacturer's specification of flatness and deflection.

10.5 Sealant for joint in tank panels shall be Butyl Rubber compound with minimum of 25% recovery from compression. Joints shall be 3 mm thick and cover the full of the panel flange.

10.6 **Installation:**

Bolts shall be 12mm diameter 304 quality stainless steel bolts where in contact with water, as specified in the current Bylaw 30 requirement.

10.7 The tank size and capacity shall be as shown on the drawings.

10.8 **Testing:**

Tanks and each compartment shall be tested undertaken on completion of installation. There shall be no visible sign of water leakage over a minimum period of 24 hours.

The testing of panels and sealant shall be as listed by Water Research Centre conforming to water fittings bylaws scheme.

11. **Booster Pump Sets for Potable Water:**

a) Provide for each system, one self-contained, fully automatic packaged unit duplex pump set (each set: 2 pumps – one duty, one standby) complete with control panel and accessories and mounted upon a fabricated steel base with reinforcement, suitable for concrete infill 100% capacity, one duty, one standby. Pump casing, shaft and impeller shall be of 316 Stainless Steel construction.

Pressure setting shall be adjustable to provide water at a constant pressure. Pumps will be automatically sequenced to work alternatively to reduce wear & tear and should be operated by a pressure switch.

b) Electric motors shall be totally enclosed, fan cooled with Class F insulation.

c) Control panel shall be designed to comply with IEE wiring regulations, latest edition. Protection shall be provided from both direct and indirect contact by earthed potential bonding and earth leakage circuit breakers.

d) Control panel equipment shall be complete with all necessary terminals, labels, interconnections, wiring and fuses. Control panel shall be constructed from sheet steel, dust and damp protected IP54 housing with anti-condensation heater and lockable door, requiring one incoming three phase, four wire electrical supply to the main isolator. All control panel labeling shall be in both English and Arabic.

e) Control panels should include pump selector switch, starters, and indicating lamps. The control panels will be designed and wired for automatic sequencing as specified above and shall also provide automatic switch over to second pump upon working pump failure.

f) Pump sets shall be protected against dry running by relay cut-off. Provide a warning lamp on the control panel to indicate when the cut-off is in operation. The pump set shall automatically resume operation when normal condition returns.

g) Pipe work, valves and fittings shall be as. Flexible connections shall be provided to both suction and discharge pipe work connections.

h) Pumps are of vertical, multi stage, and centrifugal type.

i) System piping shall be table "Y" copper brazed joints. Manifold ends shall be flanged.

j) Valves: All bronze valves at suction and discharge of each pump and bronze water type self-closing (non-slam) check valve at discharge of each pump.

k) Brass frame: Fabricated steel with resilient mounting for pumps, where required.

l) Relief Valve: Bypass pressure relief valve shall be provided from discharge to suction manifolds to prevent pump operation at shutoff head.

m) Accessories: Compound gauge at suction manifold and pressure gauge at discharge manifold, flexible connections at suction discharge connections and pressure switches.

n) Finishing: The assembly shall be given two coats of primer and one coat of gloss enamel at the factory.

o) Capacity: Shall be as indicated on the drawings.

p) Approved Manufacturer: GRUNDFOS, K.S.B, EBARA or equal.

12. **Central Drinking Water Filter** – 316 Stainless Steel Filter: - Multi-media (Sediment Removal) – Automatic system for domestic service water.

Supply and install: Filters of multi-media type, location and duty as shown on drawing. The duty GPM should be achieved when the flow rate is 10 GPM/sq.ft/bed area.

Operation: - Filter will be fully automatic backwash by using top mount automatic Bronze Valve.

i) Filter Vessel: Filter tank should be fabricated from 316 Stainless steel. Working pressure 100 PSI and testing pressure 150%.

Tanks have optional hand holes and manholes in the head and side shell for easier maintenance and loading of the media bed. Tanks 8 inch to 16 inch in diameter have with a bottom base skirt while 20 inch to 42 inch in diameter utilize structural "angle" legs for support.

ii) Distribution: Filters have hub/laterals lower distribution system. That system should be design maximum service flow and efficient utilization of the entire media bed, during the filtration and backwash process loss be minimum. All parts of internal distribution should be precision injection molded for trouble free services and made of UPVC piping and fitting.

iii) Filter media: Filter media should be high quality multi-media which consist of 5 layer and can achieve 5 micron efficiency and suspend solids, silts, clay and dirt from water. The filter media should allowing high flow but minimum head loss.

iv) Automatic Controls: The operation cycle shall be accomplished by the opening and closing bronze body control valves which are built for durability and corrosion resistance. The valve should be equipped with Teflon-coated, motor driven brass piston for smooth operation. It is a time-tested hydraulically balanced piston , seal and spacer concept applied to effectively pilot service flow and regeneration. All automatic system backwash cycles are initiated by a fully adjustable calendar time clock control.

v) Approved Manufacturers:

1. Savana Water Treatment, Canada
2. Culligan, USA
3. Bruner, USA.
4. Equal and approved.

13. Central Electric Water Heater

The water heater shall be heavy duty commercial type and shall be UL listed. The tank shall be of steel, constructed according to ASME standards for a working pressure of 125 psi. The tank shall be glass lined for protection against corrosion and shall be permanently bonded to the entire inner surface of the tank at 1600^0F. The tank shall be insulated with heavy foam or fiber glass to meet the thermal efficiency standard specified in ASHRAE/IESNA 90.1 and encased in 16 gauge galvanized jacket and finished with acrylic enamel.

The heating elements shall be heavy duty medium wattage density with incoloy sheathing. In addition the electric heater shall include the following features:-

- Magnesium anode rods
- Temperature and pressure relief valve
- Hinged door with key and lock and safety door interlock.
- Hand hole/manhole cleanout
- Factory supplied skid base.
- Internal fusing.
- Immersion thermostats
- UL certified magnetic contactors.
- Manual reset high limit.
- 180^0F operation.
- Low water cut off.
- Pilot lights.
- Manual limiting switches.
- Alarm bell.
- Low or high pressure switch.
- 7daty time clock.
- Temperature and pressure gauge.
- Modulating control, with first element.
- Suitable for 415 V/3Ph/50Hz.
- Three year warranty.
- Pipe mounted hot water circulating pump of 316 stainless steel construction.

END OF SECTION

SECTION - 4G.3

DRAINAGE

CONENTS

SECTION - 4G.3

DRAINAGE

1 **GENERAL**

Unless otherwise stated in these specifications, all drainage works shall comply fully with BS or any other Internationally recognized Specification and Standards.

2. SCOPE OF WORK:

Drainage work under this section and covered by these specifications shall include supply and installation of the following:

a) Soil and waste water pipes, as per drawing and BOQ. All pipes shall be concealed. No exposed pipes shall be accepted.

b) Ventilation Piping.

c) Sanitary fixtures as per B.O.Q.

3. **PIPES AND FITTINGS**:

All soil and ventilation pipes and fittings shall be high density poly ethylene (HDPE) conforming to DIN 19535 & 19537.

4. **FIXING AND SUPPORTING OF PIPES**:

4.1 Piping system shall be supported by means of approved hanger or supports and in accordance with ASTM D2321.

Piping shall be supported to maintain the required grading and fixing of lines to prevent vibration and to secure piping in place. The work must be to the complete satisfaction of the Engineer.

4.2 Horizontal overhead pipes shall be supported with single or multiple type hangers consisting of inserts, clevis, clevis rods, turn buckles with lock nuts and clamps or other methods of suspensions approved by the engineer. Horizontal pipes running near the wall may be supported with hangers suspended from wall brackets. The rod size for pipes 2 inches or less in diameter shall be of not less than 3/8 inch for larger size pipes shall be not less than 0.5 inch.

4.3 The spacing and hangers or supports for horizontal and vertical piping shall be the site

4.4 Vertical pipes shall be supported with galvanized mild steel pipes, clamps, special cast iron pipe rests, base fittings or by any other method approved by the Engineer.

4.5 Where several vertical pipes are installed parallel in the pipe space, the vertical pipes shall be supported on at least 50 x 50 x 5 cm. galvanized steel channels of suitable length resting at even intervals between pipe surfaces and bolted tightly around the pipes with not less than 12 mm. diameter galvanized steel "U" clamps. The channels shall be secured and welded on the building at every floor.

4.6 Vertical piping shall be adequately supported at their basis by suitable hanger placed in the horizontal line near the risers.

4.7 All risers shall be erected plumb and true and shall be parallel to walls and other pipes and neatly spaced.

4.8 Fixing brackets and clips for pipe supports shall comply with BS 1494.

4.9 Sample of all pipes, pipe supports and hangers shall be submitted to the engineer for approval before installation.

5. **SANITARY FIXTURES**:

All sanitary fixtures shall be of an approved quality obtained from an approved manufacturer. Sanitary fixtures and their connections, services, wastes, etc., shall be located as shown on the drawings and shall be designed and installed to the satisfaction of the engineer.

5.1 Sinks shall be stainless steel complying with BS 1244 fitted with chromium plated exposed sink mixer with swivel spout and aerator combined overflow and 1.5" diameter trapped waste, plug and chain. Sinks shall be fixed on pair of cantilever brackets built into the wall or on frame and supports of 1" diameter galvanized steel pipe or on block work piers or as directed by the engineer.

The following shall be minimum size of sinks:

Double bowl	1800 x 500 mm
Single bowl	1500 x 500 mm

Each sink shall be provided with powder coated steel cabinets. The size of the cabinet shall be 1500 x 500 mm for single bowl and 1800 x 500 mm for double bowl. The height shall be 900mm approximate. The top plate shall be of stainless steel.

5.2 Asiatic water closet suites shall comprise of glazed fireclay squatting slab, plain "S" or "P" trap 3½" bore outlet, two gallons capacity high or low level white glazed fireclay **water saving double mode flushing cistern** fixed to walls with cantilever brackets of concealed fixing, 1¼" (high level) or 1½ " (low level) diameter flush pipes, non-corroding valveless syphon, ½" low pressure ball valve and union, ¼" overflow and union, and either flushing handle or pull and chain. In a position adjacent to each Asiatic water closet,

a suitable water draw-off point with flexible hose shall be provided. The WC shall be of coloured type and the colour shall match with the surroundings.

5.3 European water closet suites shall comprise glazed fireclay pan complying with BS 1213, having "S" or "P" trap with 3½" bore outlet, two gallons capacity low level white glazed fireclay **water saving double mode flushing cistern** fixed to the WC 1½" (low level) diameter flush pipe, non-corroding valveless siphon, ½" low pressure ball valve and union, ¾" overflow and union. In a position adjacent to each water closet, a suitable water draw-off point with flexible hose and health faucet shall be provided. The WC shall be of coloured type and the colour shall match with the surroundings.

5.4 Urinals shall be of wall fitted bowl type urinals of glazed fireclay. The bowl shall be supported on steel brackets cut and pinned to wall and shall have chromium plated flat grating and outlet. The urinals shall be directly connected to water supply with 0.5" valve. The urinals shall be of pleasing colour subject to the approved by the engineer. Each urinal shall have an independent automatic electronic flushing system.

5.5 Bidet shall be glazed fireclay with 3 tap holes for mixer and douche. It shall be fitted with pop-up waste. Bidet shall be fixed in a suitable location near the European WC. The color shall be with the color of the other fixtures.

NOTE: Wash basins and bidet of glazed vitreous china clay may be accepted in lieu.

5.6 **Wash Basin** :

Wash Basins shall be in pedestal type enameled glazed fireclay complying with BS 1188, fitted with centre set cold and hot,**water saving automatic electronic faucet fitting** (Grohe or equivalent) with aerator and pop-up waste combined overflow and 1.25" diameter trapped waste, plug and chain. Wash basins shall be fixed on pair of cantilever brackets built into walls, or counter monunted as shown in drawing.

5.7**Shower & Shower Tray**

Shower tray is vitrified porcelain, dimension 800 x 800, with 1¼" trapped strainer waste ½" bath shower mixer with transfer valve, shower arm with swivel shower head, all chrome plated.

5.8 **Accessories**:

The following fittings shall be provided:

a. Adjacent to European water closet, porcelain, a chromium plated or enamel paper holder.

b. On the wall adjacent to wash basin:

1. A Chromium plated or enamelled towel rail with end brackets.
2. Mirror over wash basin of approved quality and make. (Size: 240 x 600mm)
3. Wash basin tray.
4. Paper towel dispenser.
5. Soap dispenser.

6. WASTE SOIL AND VENTILATION PIPES

6.1 General

a) Unless otherwise shown on the drawings all internal pipe work shall be concealed in ducts, false ceilings or chases in concrete or brick walls or under tiles unless otherwise directed by the engineer.

b) Where tiling is cut around waste water pipe, suitable diameter chromium plated steel cover plates shall be used, but in no case less than 2" outside diameter.

c) Where practicable, pipe work shall be carried out as the building proceeds so as to minimize the amount of cutting away and repairing

d) The contractor is responsible for the correct making-out of the positions of all necessary holes in walls, floors, ceilings, etc., for pipes and pipe supports. No pipe fixtures or other apparatus shall be installed in such a way as to interfere in any way with the full opening of the doors.

e) The arrangement of all piping shall be approximately as shown on the drawings and as directed by the engineer during installation. They shall be as straight and direct as possible forming right angles or parallel lines with building wall and other pipes and neatly spaced.

f) Clearance between exposed pipes and the finished surface of all partitions or ceiling shall not be less than 50mm.

g) Horizontal runs of piping except where concealed in partitions or in floor (under tiles) shall be kept as high as possible and close to walls.

Consult the contractors of all trades so that pipeline will not interfere with each other.

h) Ends of pipes shall be plugged to prevent dirt accumulation in pipelines.

i) When openings are made in foundations of walls for the spaces between the opening around the pipe shall be closed with brick or concrete as approved by the engineer.

6.2 Soil & Waste Piping

Drainage piping included under this section shall cover all soil waste water piping inside the buildings and out to the nearest manhole or as shown on the drawing and as directed by the engineer. The following points shall be adhered to in the installation of all internal drainage piping.

a) Pipes shall be fixed in straight lines and have a uniform slope as stated in the following table, except where such slopes on overhead space more than an allowable, the slope may be reduced, if so directed by the Engineer.

Pipe size	Slope percentage
4" and less	2%
6" and more	1%

No branch drain shall have a flatter slope than given for the main drain to which it is connected.

b Outlet sockets and end of soil and waste pipes shall be set to the correct distance from the face of the floor or wall or ceiling to make a good joint with the piping and the sanitary fittings.

6.3 Ventilation Piping:

The soil piping shall be provided with a system of vent piping to permit the admission of air. The vent piping shall be installed as shown on the drawings and as hereunder described:

a. Top ventilating pipes shall project through walls on roof to vent the air at the point shown on the drawings. The ventilating pipes shall be fitted with galvanized steel ball on grating at the top.

b. The top of any vent shall not be directly beneath any door window or other ventilating opening of the buildings and shall not be within 3 m horizontally of such an opening unless it is at least 100 cm above the top of such an opening.

c. Vent pipes shall be graded and connected as to drip back to the soil or waste pipe by gravity.

d. Vent piping connected to horizontal soil or waste pipe shall be taken off above the centre line of that pipe.

   The vent pipe shall rise vertically or inclined at an angle not more than 45° from the vertical, to a point at least 200mm. above the flood level rim of the fixture it is venting before off-setting horizontally or before connecting to the branch vent.

e. The point of connection between the vent pipe and the vent stack shall be made at least 200mm. above the flood level rim of the highest fittings. Served by the vent, horizontal vent shall be at least 200mm. above the flood level rim of the highest fitting served.

7. **FLOOR DRAINS & CLEAN OUTS**:

Floor drains shall be installed in suitable locations as directed by the engineer.

Floor drains shall be of heavy duty cast Iron body with grating in nickel bronze finish. Each floor drain shall have an integral or separated P-trap and necessary raising pieces with the necessary side inlet opening (or openings) and with heavy duty perforated floor trap covers. Floor cleanouts and Ground cleanouts shall be of heavy duty cast iron with air tight covers in nickel bronze finish. Make Josam / Wade / Smith or equal.

8.**TEST:**

Before any fixture is connected, the water test shall be applied to the drainage system, either in its entirely or in sections. No section shall be tested with less than 3M head of water.

9.**CLEANING**:

The contractor shall carefully clean out all sanitary fittings throughout straps, wastes and all pipes.

The contractor also shall leave all works in perfectly clean and working condition.

10. Working drawings, as fitted drawing, microfilm, other documents refer HVAC Section.

END OF SECTION

SECTION – 4G.4
FIRE PROTECTION

CONTENTS

SECTION –4G.4
FIRE PROTECTION

PART 1 – GENERAL

1.1 GENERAL REQUIREMENTS

A. The Contractor shall comply with all other Sections of the Specifications for requirements that affect work of this Section whether or not such work is specifically mentioned in this Section.

B. The Contractor shall co-ordinate work with that of all other trades affecting or affected by work of this Section.

C. The Fire Protection Contractor shall be Grade 1 registered with Kuwait Fire Department (KFD).

1.2 SCOPE

A. Design, supply and install a comprehensive Fire Fighting System to the requirements and approval of Kuwait Fire Department (KFD). The fire protection system shall include, but not limited to the following: -

1. Foam extinguishing system for Generators.
2. Deluge system for transformers.
3. Total flooding system using any gas approved by Kuwait Fire Department for HT room, LT room, UPS room and Control room
4. Portable Fire extinguishers, fire hoses and fire cabinets.
5. Fire hydrants with fire water mains around the buildings.
6. Main fire pumps & jockey fire pumps with all the accessories and their arrangement in fire pump room.
7. The entire fire fighting system to be suitably supplemented by a fire detection and the alarm system.
8. Any other protection systems are required mandatory by Kuwait Fire Department (KFD).

B. Prepare detailed design and obtain approval from KFD

C. Prepare shop drawings.

D. Obtain the approval of the Engineer for the shop drawings prepared.

E. Obtain the approval of the KFD for the shop drawings along with related engineering calculations.

F. Provide all labour, materials, services equipment & transportation required to install, complete test and commission and ready for continuous operation, all fire fighting systems, as per the drawings approved finally by Engineer as well as KFD.

1.3 QUALITY ASSURANCE

A. **Reference Standards, Codes, Standards, Rules and Regulations:**

Without limiting the generality of other requirements of these Specifications, all work specified herein shall conform to or exceed the applicable requirements of the following authorities or agencies to the extent that their requirements are not in conflict with the provisions of this Section:

1. Kuwait Fire Department (KFD)
2. Ministry of Electricity and Water, Kuwait (MEW)
3. National Fire Protection Association (NFPA), USA
4. Underwriters Laboratories, Inc. Standards (UL), USA
5. Fire Officer's Committee (FOC), UK
6. British Standards Institution (BSI), UK
7. Loss Prevention Council (LPC), UK

B. The Works covered by this Section shall be executed by experienced tradesmen, engaged in the installation of fire protection systems for at least three (3) immediately preceding years. The installer shall have a Class I registration as Fire Protection Contractor with the Kuwait local Fire Department as required.

C. The Contractors shall submit the shop drawings and materials used for the works covered by this Section to the Kuwait Fire Department (KFD) and obtain their approval. KFD approval shall be submitted to the Engineer prior to placing any order or proceeding with any installation.

D. Only those products specifically listed / approved for Fire protection services; by Underwriters Laboratories Incorporated USA, Factory Mutual Testing Laboratories USA, Fire Offices Committee of UK, Loss Prevention Council (LPC), UK or other approved agencies of international repute; shall be used, where stipulated.

E. Materials incorporated in the work covered by this Section shall be, new products in good condition. Materials spoiled due to improper storage or mishandling shall be rejected.

F. Materials of similar nature shall be products of the same manufacturer. Mixing up products of different standards or those of different manufacturers shall not be permitted for the same service.

G. Materials to equivalent British (BS), German (DIN), or Japanese (JIS) or other international standards are acceptable, provided that the Contractor substantiates their equivalence and ensures their compatibility with other components of the system. Copies of the current version of the reference standards shall be submitted for comparison, if required by the Engineer.

H. All copper alloys used in the construction of valves, pipe fittings, fire protection specialities etc., which come in contact with water; shall be dezincification resistant type.

I. Requirements of AWS code shall be conformed to in respect of welding materials and procedures and welders shall be certified in accordance with ASME Section 9.

J. Test certificates for materials used in the work covered by this Section, from approved independent laboratories or testing agencies, shall be furnished at no extra cost if required by the Engineer.

1.4 SUBMITTALS

A. The Contractor shall submit samples as requested by the Engineer of all materials specified herein in accordance with the requirements of the Contract Documents and, before ordering, obtain written approval from the Engineer.

B. **Manufacturer's Data**

1. Prior to submission of the shop drawings, The Contractor shall submit to the Engineer lists of all equipment and materials with the names of proposed manufacturers. Shop drawings will not be accepted prior to submission of such lists.

2. Drawings of equipment and material shall include detailed manufacturer's drawings, cuts of catalogues, and descriptive literature, showing specifications, type, performance characteristics, construction, component parts, dimensions, size arrangement, operating clearances, capacity, electrical characteristics, power requirements, and testing information. Data of a general nature will not be accepted.

3. Catalogues, pamphlets of manufacturer's drawings submitted for approval shall be clearly marked in ink for proper identification of the item being proposed. Deviation from the Specification and the Drawings shall be indicated clearly with the reason for each deviation.

4. The Contractor shall submit original catalogues of manufacturers' data for all pipes, sprinkler heads, spray nozzles, foam water sprinklers, valves, foam generating equipments, detectors, panels etc. No equipment or material shall be installed, delivered to site or purchased, until the Engineer has approved the items and each catalogue is stamped "approved" by the Kuwait Fire Department.

C **Drawings**

1. The following shall be considered and provided for the preparation and approval of drawings:

   - Clear architectural drawings without dimensions but with equipment layout (with thin dotted line) shall be used for fire fighting system.
   - Conceptual layout drawings shall be 1:100 scale.
   - Shop drawings shall be 1:50 scale or 1:100.
   - Details / equipment room drawings shall be 1:20 or 1:50 scale.

- Fire zone drawing shall be 1:200 scale.
- Each drawing shall have separate number.
- Penetration drawings through all civil works shall identify all types of operating for different trades with fire sealing details.
- Separate drawing for each floor / each system.

2. **Working / Shop Drawings**

After the approval of system description, conceptual layout and design calculation, working / shop drawings with sections and details shall be submitted for approval.

- Submit Shop Drawings for Engineer's approval. Show plans, elevations, details and job conditions, relationship to other work, and indicate finishes.
- Shop Drawings shall be coordinated with the work of all other trades.
- All drawings shall be approved by the Engineer and stamped "approved" by the Kuwait Fire Department before starting any work.
- Approval rendered on drawings shall not relieve the Contractor from his responsibility to provide equipment and material to meet the performance and quality standards as indicated on the Drawings and as described in the contract.

D. **Calculations**

The Contractor shall submit:

1. Full hydraulic and design calculations for the standpipe and hose system, fire water storage tanks, fire & jockey pumps etc in accordance with NFPA codes, KFD requirements.
2. Full design calculations for all the systems of fire protection including special systems like foam water, deluge system for transformers, …. etc.
3. All calculations shall be based on the actual installation layouts shown on the shop drawings. All calculations shall be subject to the approval of the Engineer and the Kuwait Fire Department.

E. **Submittals for Fire Brigade**

1. The Contractor shall submit all fire protection shop drawings, catalogues and engineering calculations to the Engineer for approval. After the shop drawings, catalogues and engineering calculations have been approved by the Engineer prepare at least three complete sets of shops drawings, catalogues and engineering calculations. At least one catalogue for each item shall be an original catalogue, not a photocopy. The sets must be prepared specially for submission to the Fire Brigade and must be contained

within separate folders. Each folder must contain an index sheet listing the shop drawings and the catalogues. Each shall be stamped with an identification stamp.

2. Where several items are shown on submitted catalogue the specific item requiring approval must be clearly indicated. If an item is to be included or items are to be excluded, these facts must be clearly shown on the submittal. The shop drawings, catalogues and engineering calculations which are to be submitted to the Fire Brigade shall be submitted through the Engineer.

F. **Record Drawings**

1. The Contractor shall provide and keep on the job at all times, one complete and separate set of black line prints of the fire fighting works on which shall be clearly, neatly and accurately noted, promptly as the work progresses, all changes, revisions and additions to the work. Wherever work is installed other than as shown on the Drawings, such changes shall be noted.
2. The Contractor shall indicate daily progress on these prints by colouring in, the various pipes, fixtures, apparatus and associated appurtenances as they are erected.
3. At the conclusion of work, the Contractor shall prepare Record Drawings.

G. **Operation and Maintenance Manual**

An "Operation and Maintenance Manual" shall be submitted with complete data for each piece of equipment installed, as detailed below:

1. The manual shall contain:
   a. Table of contents.
   b. Fire protection materials submittal with the / Architect's / Engineer's / and KFD approval.
   c. Manufacturer's installation instructions.
   d. Manufacturer's internal wiring diagrams, if any.
   e. Manufacturer's assembly details.
   f. Replacements parts / materials, number listing and description.
   g. Preventive maintenance schedules listing frequency of service and or replacement.
   h. Lubricants, commercial equivalents and schedules of use.
   i. Name and address of manufacturer's sales and service agencies and local representative / distributor including telephone and telex numbers.
   j. Name and address of Contractor's maintenance department including emergency contact telephone number.

2. The contents of the manual shall be arranged in sections with tags, grouping each class of equipment as fire extinguishers; fire cabinets; floor control assemblies, deluge stations; valves; fire protection specialities like foam systems, monitoring and alarm systems etc.

3. Contents of each section shall be arranged in the sequence as listed above (item 1).

1.5 WORKMANSHIP

A. The entire work shall be constructed and finished in every respect in a workman like and substantial manner. It is not intended that the drawings shall show every pipe fitting and appliance, but the Contractor shall furnish and install all such parts as may be necessary to complete the systems in accordance with the best trade practice and to the satisfaction of the Engineer.

B. If any departures from the drawings are deemed necessary, submit details of such departures and the reasons thereof as soon as possible to the Engineer for approval. No such departures shall be made without the prior written approval of the Engineer.

C. The drawings showing foam, FM-200 / Inergen & deluge systems are indicative only and should not be regarded as final installation drawings. The Contractor shall be responsible for preparing the detailed design and shall submit fully engineered and coordinated system for each of foam, FM-200 / Inergen & deluge system.

1.6 CO-ORDINATION

A. The Contractor shall co-ordinate with the civil and building works the shape, size and position of all openings required for apparatus sufficiently in advance of the work so that all openings are built-in advance.

B. The Contractor shall obtain detailed information from the manufacturers of apparatus as to the proper method of installing and connecting their equipment. Coordinate all information between Trades as necessary to facilitate the work and the completion of the Works.

C. The Contractor shall make any change from the Drawings necessary as approved by the Engineer to make the work conform to the Works as constructed and/or fit the work of other Trades or Sections of the work, or to conform to any and all prevailing rules or codes changes.

D. The Contractor shall check the layout of the piping, fixtures, tanks, machinery, etc., as indicated on the Drawings and determine the exact locations by the dimensions of the equipment and apparatus approved. Obtain the Engineer's approval for the revised layouts before equipment and apparatus are installed. Coordinate all Shop Drawings for all dimensions, locations of partitions, locations and sizes of structural supports, foundations, trenches, opening, etc.

E. The Contractor shall provide all sleeves for passage of pipes through structural masonry and concrete walls and floors and elsewhere as required for the proper protection of each pipe passing through building surfaces.

F. The Contractor shall provide required supports and hangers for piping and equipment, so that loading will not exceed allowable loadings of structure.

G. Items of equipment shall be of the quality specified and normally used for the purpose of good commercial practice and shall be the products of reputable manufacturers. Each major component of the equipment shall have the manufacturer's name, address and catalogue number on a nameplate securely fixed in a conspicuous place. The nameplates of a distributing agent only will not be acceptable.

H. All equipment shall be installed and connected in accordance with standard engineering practice and the manufacturer's instructions and recommendations. Furnish and install completely all associated piping, valves, connections, etc., recommended by the manufacturer or as required by or for proper operation of the equipment and the system.

I. All workmanship shall be of the highest standard in every respect and shall be performed only by skilled tradesmen, recognized as such in their respective trades.

J. The Contractor shall avoid the cutting or drilling of work of other Trades, finished or otherwise, wherever possible. However, if due to ill-timed work or errors in laying out of the Contractor's work, cutting or drilling can in no way be avoided, do such cutting or drilling necessary for the proper installation. The cutting and drilling must be kept to a bare minimum. No cutting or drilling of any building structural member will be permitted without the approval of the Engineer. Do all repairs to areas where cutting is carried out.

1.7 QUALIFICATIONS

A. The Contractor shall submit written proof that he is authorized by the KFD to install fire protection equipment and systems. (Only Contractors experienced for at least three (3) immediately preceding years and having Class 1 registration as Fire Protection Contractors with KFD and approved by the Kuwait Fire Department are permitted to install Fire Protection Equipment Systems).

B. Specialist with local representations shall be employed for special protection systems like foam, FM-200 / Inergen etc.

C. Where Sub-contractors are proposed, the qualifications for the Sub-contractors, Engineers and foremen shall be submitted for approval.

1.8 MANUFACTURERS

A. The products and manufacturers specified hereinafter are specified for the purpose of establishing minimum quality standards. Products equal

in quality to, or better than those specified, will be considered acceptable. Manufacturers shall have a representative in Kuwait who shall be able to provide technical support and shall hold stocks of spare parts.

B. The manufacturer's representative(s) shall provide on Site supervision as necessary or required by the Engineer or KFD during installation and testing.

1.9 CLEANING AND PROTECTION

A. The Contractor shall deliver to and store on Site with vapour-proof protection all equipment with electrical component parts.

B. The Contractor shall deliver to and store on Site with a suitable waterproof protection all equipment or component parts of equipment specifically designed to operate in normal room conditions.

C. Where a piece of equipment or an application comprises more than one part, the pieces shall be separately packed and be clearly identified on the outside with the manufacturer's name and component reference.

D. The Contractor shall protect pipes with suitable coverings as soon as set. Close all open ends of pipes with a plug fitting to prevent obstruction and damage.

E. Before final connections are made and before operation of equipment and piping, thoroughly blow out, rod out, or wash-out all piping.

F. The Contractor shall cover valve ports to prevent the ingress of foreign matter and protect flanges against damage to the flange surface.

G. The Contractor shall clean all equipment exposed to view in completed areas, by removing rust and dirt by wire brushing. Remove grease, oil, and similar materials by wiping with clean rags and suitable solvents. Remove from site all packing cartons, scrap materials, and other rubbish resulting from the installation operations. Leave premises in "Broom Clean" condition.

1.10 INSPECTION, TESTS AND CERTIFICATES

A. The Contractor shall provide all labour, materials, instruments, supplies and services and bear all costs for inspection, tests and certificates.

B. During the construction period the Kuwait Fire Department shall be called to make inspections and recommendations. The Fire Department shall be called to inspect any pipework that is to be subsequently hidden by false ceilings or enclosed within a duct, or buried underground. This work shall be carried out in such a way that the Contractor shall coordinate with the Kuwait Fire Department / local fire protection authority, facilitate their visit to site, test and demonstrate the system for their approval in co-ordination with the Engineer.

C. No work shall be covered before examination and approval by the Engineer and by all inspectors and authorities having jurisdiction. If work

is covered before due inspection and approval, the Contractor shall pay all costs of uncovering and reinstating such work.

D. During the manufacture (at Contractor's premises only) and installation and after completion of works; the system, sections of the system or its components shall be tested by the Engineer, as directed below or elsewhere. The Contractor shall procure all testing instruments and accessories and bear all costs in connection with the same. Tests shall include:

1. Basic materials for conformity with the specified standard.
2. Supports and anchors for ability to withstand required loads.
3. Piping in general for line, level and slopes.

E. The Flow Switches shall be adjusted for minimum flow for actuation.

F. The Contractor shall make adjustment, repairs, alterations as required to meet specified test results. Correct defects disclosed by test or inspection; replace defective parts. In replacing defective parts, use only new materials.

G. The Contractor shall repeat tests after defects have been corrected and parts replaced, as directed, until pronounced satisfactory.

1.11 FINAL TESTS

A. Each system shall be fully tested by the Contractor in accordance with NFPA I the presence of the Engineer and the KFD officers. Upon completion of successful tests the Contractor shall so certify in written to the Engineer.

B. The Contractor shall provide the Engineer, properly executed, all required certificates of final inspection and approval before the work will be accepted as complete.

1.12 SYSTEM DEMONSTRATIONS

A. The services of a competent engineer shall be provided by the Contractor to supervise the commissioning of all equipment and to train the Employer's personnel in all aspects of the system during a five (5) working days period. All costs in connection with the above shall be by the Contractor.

B. A minimum of one week written notice shall be given and the Engineer’s approval obtained, prior to such demonstrations.

C. The system demonstrations shall be conducted prior to Completion.

1.13 GUARANTEE

A. The Contractor shall guarantee that all elements of the systems are of sufficient capacity to meet the specified performance requirements as set out in the Specification or otherwise indicated.

1.14 MAINTENANCE PERIOD

A. The Maintenance Period for the fire protection systems shall be for one year.

B. During the Maintenance Period at 6 monthly intervals the Contractor shall undertake inspections and tests of the system to determine that the system is in proper working order.

C. Inspections and tests shall be performed by a qualified Inspector(s) who is certified by the system manufacturer(s).

D. All inspections shall be performed in accordance with NFPA 2001 and NFPA guidelines.

E. The contractor shall refill any item of equipment should there be any discharge of the system during the Maintenance Period, due to faulty parts, materials or workmanship.

PART 2 – PRODUCTS

2.1 GENERAL

Products

The products and manufacturers specified herein after are specified for the purpose of establishing minimum quality standards. Products equal in quality to, or better than those specified may be acceptable subject to the Engineers approval.

2.2 MATERIALS

A. **Pipe Work**

Use the materials specified below for various piping systems.

	SERVICE	LOCATION	TYPE
1.	External hydrant system piping & fire protection water supply main piping 80 mm nominal dia & larger.	Below ground	Ductile Iron, cement lined.
2.	Hose reel system piping up to 80mm dia.	All	Seamless heavy weight galvanised steel piping to BS 1387.
3.	Sprinkler System piping up to 80mm dia	All	Seamless heavy weight galvanised steel piping to BS 1387.
4.	Sprinkler piping 100mm dia. and above.	All	Seamless heavy weight black steel pipes to BS 3600/3601, Grade 410.
5.	Foam system pipe work 80mm dia. and below.	Generator Building and diesel storage tanks area.	Seamless heavy weight black steel to BS 1387.
6.	Foam System pipe work 100mm dia. and above.	Generator room area and diesel storage tanks area.	Seamless heavy weight black steel pipes to BS 3600/3601, Grade 410
7.	Surface cooling water spray system for diesel	Diesel storage tank	Seamless heavy weight black steel

	SERVICE	LOCATION	TYPE
	storage tanks, pipework up to 80mm dia.	area.	pipes to BS 1387.
8.	Surface cooling water spray system pipe work above 80mm dia.	Diesel storage tanks.	Seamless heavy weight black steel pipes to BS 3600 / 3601, Grade 410
9.	Water deluge system piping up to 80mm	Transformer room.	Seamless heavy weight galvanised steel piping to BS 1387.
10.	Water deluge system piping above 80mm dia.	Transformer room.	Seamless heavy weight black steel pipes to BS 3600 / 3601, Grade 410

B. Pipe Joints and Fittings

1. The Contractor shall use the following pipe joints and fittings for the standpipe and hose systems: -
   a) Pipe work 80 mm diameter and below, use BS 143 / BS 1256 galvanised malleable iron fittings with BS 21 screwed taper threads.
   b) Pipe work 100 mm diameter and above, use one of the following: -
      (i) Butt welding using fittings conforming to BS 1965, Part I.
2. The Contractor shall use the following pipe joints and fittings for foam pipe work: -
   a) For pipe work of 80 mm diameter and below, use BS 143/BS/1256 black malleable iron fittings with BS21 screwed tapered threads
   b) For pipe work of 100 mm diameter and above, use one of the following: -
      (i) Butt welding using fitting conforming to BS 1965, Part I.
3. The Contractor shall use the following pipe joints and fittings for FM-200 pipe work: -
   a) Up to 80mm and below:
      (i) Malleable, threaded to ANSI B-16.3, class 30, materials conforming to ASTM A-197.
      (ii) Forge steel fitting threaded to ANSI B-16.11, class 2000 materials conforming to ASTM A-105.

b) Over 80mm dia:

(i) Butt welding using fitting conforming to BS 1965, Part I.

C. Hangers, Inserts, Anchors and Pipe Supports

1. All piping shall be supported by means of approved supports. Piping shall be supported to maintain required grading and pitching of lines, to prevent vibration and to secure piping in place. It shall be so arranged as to provide for expansion and contraction.

2. The Contractor shall provide in an approved manner all hangers, brackets, supports, anchors and related appurtenances, as required to support all piping and equipment provided under this Section of the work as detailed in 3-15 of NEPA-13. All piping fixing by means of hangers etc. shall be acceptable to the relevant standard code of practice, the Kuwait Fire Department and the Engineer.

3. Horizontal overhead pipes shall be supported with single or multiple type hangers consisting of inserts, clevis rods, turn buckles with locknuts and clamps or other methods of suspension suitable and adequate, so that loading will not exceed allowable loadings of structure. Drilling, cutting and/or reinforcing of holes in concrete structures shall be coordinated throughout the works and approved by Engineers. Do not hang piping from duct work or other piping.

4. Vertical Pipes shall be supported with steel pipe clamps, special cast iron pipe rests, base fittings, or by other approved methods suitable for the type of building construction. Where several vertical pipes are installed parallel in the pipe space, the vertical pipes shall be supported on at least 100 mm. by 50 mm. galvanised steel channels resting at even intervals between pipe surfaces and bolted tightly around the pipes with not less than 12 mm. diameter galvanised steel "U" clamps or least 25 mm. by 3 mm. galvanised steel plate. The channel shall be secured and welded on the building structure at every floor.

   Spacing of clamps for support of vertical piping shall be close enough to keep the pipe in alignment, prevent rattle and vibration and to support the weight of the piping and fittings. In no case shall they be more than the floor height.

   Vertical piping shall be adequately supported at their bases either by a suitable support placed in the horizontal line near the riser or by a base fitting set on a pedestal or foundation and at the middle of every floor with a riser clamp.

5. The general requirements for pipe supports are as follows:

a. The maximum distance between hangers shall not exceed 3.7m for 25mm and 32mm diameter pipes and 4.6 m for 40 mm dia or larger pipes.

b. Pipe work joints by the chemical coupling technique shall be supported as recommended by the coupling manufacturer.

D. Pipe Sleeves

1. Sleeves shall be provided for all pipes that pass through slabs, partitions or other building construction.

2. All vertical pipes in open chases or shafts shall be provided with galvanised sleeves where allowances are required for expansion of pipes or where chases or shafts are to be grouted in after work is installed.

3. Sleeves through walls, floors and partitions shall not be less than 0.5 mm thick galvanised steel sheet or made of galvanised steel pipe.

4. The Contractor shall provide approved fire stopping to all pipe sleeves passing through floors, fire protected shaft walls and fire rated walls. Provide approved fire stopping for the complete sleeve length.

E. Valves:

1. The Contractor shall provide valves as specified and/or indicated on the drawings.
2. Each valve shall be marked with cast-on or stamped lettering giving the following information.
   a. Manufacturer's name or trademark.
   b. Size of valve
   c. Guaranteed working pressure
   d. British Standard or other International Standard where applicable.
3. **Gate Valves:**
   a. Valves 50mm dia. and smaller shall be generally of bronze construction with screwed ends, rising stem and conforming to BS5154, PN16 Series B.
   b. Valve 65mm dia. and above shall be of cast iron, flanged construction with zinc-free bronze trim outside screw and yoke, rising stem. The valves shall be PN16 and Comply with BS5150.
4. **Silent Check Valves:**

a. Up to 50 mm (2 inch) nom. size: Bronze, in-line, resilient seat and disc, spring loaded, screwed ends.

b. Over 50 mm (2 inch) nom. size: Iron body, bronze trim, spring loaded, renewable composite disc and seat, flanged ends.

c. Over 50 mm (2 inch) nom. size: Iron body, bronze trim, swing type with external lever and weight, renewable seat and disc, flanged ends.

Each check valve shall be provided with a suitable test cock to facilitate back flow testing.

All valves shall be "Factory Mutual" approved.

5. **Drain Valves**

a. Bronze angle globe pattern, key operated, threaded inlet and hose connection outlet with cap and chain.

6. **Pressure Ratings**

a. All valves shall be rated for 200 psi working water pressure at 121°C (250°F), unless otherwise indicated.

b. The Contractor shall allow for selecting higher pressure rated valves to meet the valve construction features.

7. **Valve operators**

a. Hand wheels / operating levers shall be provided for valves as appropriate. Hand wheels for gate and globe valves 50mm nominal dia and smaller, shall be non ferrous metal (die cast zinc/aluminium alloy etc.)

b. One key/wrench of appropriate size shall be provided for each lever operated valve installed.

c. All wheel-heads shall be clearly marked showing in which direction the wheel should be turned to close the valves.

d. All valves shall be provided with an "Open and Shut" indicator.

e. All valves other than those monitored by a supervisory switch shall be provided with a wheel head locking device secured by a padlock, so that they can be locked in open position.

f. All valves which are monitored by a supervisory switch shall have the stem notched and any other amendments as necessary for the correct installation and operation of the supervisory switch.

8. **Acceptable Manufacturers**:

a. Nibco

b. Kitz

c. Crane

or from any other manufacturers with equivalent or better product.

F. Fire Protection Specialities

1. **Floor Control Assembly**:

   a. Shut-off Valve with Supervisory Switch for alarm: Bronze body, butterfly valve with built-in micro switch, visual position indicator, operating handle and threaded ends, rated 12 bars (175 psi) working water pressure. Use pressure reducing type where required.

      Ref: Milwaukee BB-SCS 01/ watts 500 (s) with supervisory switch or approved equal.

   b. Power Supply and Alarm Unit: Power supply transformer, bell, power on (green) and valve closed (amber) indicators, all in welded sheet metal enclosure (NEMA 4) suitable for surface mounting.

   c. Flow Switches:

      Vane type flow switches with volt free, normally open contacts rated for 5 amps at 250 volts A/C (max) and enclosure with tapped conduit entry. The flow switch shall be installed properly in accordance with manufacturer's recommendations, to signal any water flow condition that equals or exceeds the discharge from one sprinkler. The electric signal shall be transmitted to the fire alarm system.

   d. Pressure Gauges:

      Pressure gauge shall be of the "bourdon tube" type with a dial not less than 100 mm in diameter. The dial shall be graduated in bars/ psi. The graduation shall be from zero (except for compound pressure gages) to not less than one and half times and not more than three times the working pressure. The gauges shall be fitted with a cock or valve so that the gauge may be shut-off and removed while the pipeline is in operation.

   e. Metering orifice: Union assembly, with brass orifice, sized to give flow equal to the discharge of one sprinkler.

      Ref: Gem Fig. 1266 or approved equal.

   f. Sight Glass: See through, window flow indicator with threaded ends.

      Ref: John C. Earnest Catalogue no. 131 or Approved equal.

   g. Test and Drain Valve: All bronze, rising stem construction with screwed ends, solid wedge and union bonnet.

      Ref: Nibco-Scott T 211 or approved equal.

2. **Sprinklers**: All sprinklers shall be automatic glass bulb type, standard orifice (15 mm) colour coded as follow:

   68°C.....Red

   79°C.....Yellow

93°C .... Green

a. Air Conditioned Areas with False Ceiling: Chrome plated brass, spray type, rated 68°C, installed pendant with matching ceiling plates.

b. Air Conditioned Areas without False Ceiling: Spray type, chrome plated brass, rated 68°C installed pendant.

c. Non-Air Conditioned Plant Rooms and Other Areas: Chrome plated brass, conventional type, rated 79°C installed upright or pendant as appropriate.

d. Up right Sprinklers: Upright pattern Conventional Sprinkler with plain brass finish with in false ceilings and chrome plated for exposed conditions, temperature rating 68°C.

e. Approved manufacturers are:

Viking; Jomos DAA or from any other manufacturer with equivalent or better product under the provisions of General Conditions of Contract. All sprinklers shall be supplied by one manufacturer unless agreed otherwise by Engineer.

3. **Sprinkler Line Testers**:

a. Forged Brass fitting with 25 mm (1 inch nominal) female threaded inlet, 15mm (½ inch nominal) threaded sprinkler outlet and 25 mm (1 inch nominal) male hose threaded, drain outlet with cap and chain. The drain valve shall be wrench operated.

Ref: Potter-Roemer Fig. No. 6175 Elkhart No. 112 or approved equal.

Note: Item 1-4 above required in case of sprinkler installation.

4. **Fire Cabinets** :

a. Fire cabinets shall have fabricated sheet steel enclosure; all joints of the cabinet shall be welded and round smooth. Hinges shall be solid, pin type machined from steel rods and welded to cabinet and door. Door edges shall be boxed and shall have recessed strip type hand pull in stainless steel. Adhere foam rubber strips to door frame and to make the enclosure dust proof. Fire cabinet shall be suitable for fully recessed installation and have an architrave to cover the frame. Size shall be as detailed in the drawings.

Contents of fire cabinets:

(i) 25 mm (1 inch) nom. dia, automatic hose reel, 30 ms (100 feet) long with jet / spray nozzle suitable for 17 Bars (250 psi) working water pressure, complete with lockshield type isolating valve.

(ii) 6 kg. dry powder extinguisher

(iii) 9 litres (2 gallons) water pressure extinguisher.

b. All fire cabinets, fire extinguishers and other contents of the fire cabinet are subject to the approval of the Engineer and KFB. The fire extinguishers shall be manufactured by Angus Fire Armour of England or other equal and approved manufacturer.

5. **Fire Cabinets Outdoor:**

1. A floor mounted reinforced glass film cabinet with proper reinforcement, painted red to accommodate the following shall be provided next to each hydrant in the yard.

2. Two fire hoses 65mm dia, 30mm long, made of polyester filament yarn, BI compartment lining / double jacket type internal and external lining with reinforcement.

65mm dia male/female instantaneous couplings according to BS 336 in bronze or aluminium at both end of hose.

Two discharge nozzles 250 GPM flow @ 5bar, twist adjustable fog nozzle (iii) one hydrant operation key (iv) one axe long size according to DIN 7294. The instantaneous couplings must be compatible with the couplings of the hydrant.

Pressure at nozzle outlets shall not exceed 5 bars, if required, pressure reducing valves shall be provided.

6. **Fire Extinguishers:**

a. Mobile Fire Extinguishers

Mobile fire extinguishers with dry powder with a capacity of approx 25/50 kg net shall be provided in different areas of the project mainly in electrical rooms and equipment tank rooms. The mobile fire extinguishers shall be mounted on hand carts and furnished with a 6m hose each. Location, capacity and number of extinguishers shall be as shown on the drawings.

b. **Portable Fire Extinguishers (wall mounted)**

Portable 9 litre foam water extinguishers shall be installed in diesel service tank. They shall be normally pressure free with internal CO_2 cartridge. The foam spray shall be interruptible by means of a hand valve and shall be directed by a short flexible hose. ABC dry powder extinguishers shall be provided as shown in the drawings or BOQ.

The maximum travelling distance to an extinguisher shall not exceed 25m.The maximum area to be protected shall not exceed 500m^2 per extinguisher.

The fire extinguishers shall be provided as early as possible, however, not later than on commencement of the commissioning preparations.

After completion, random functional tests of 5% of the supplied portable extinguishers shall be performed in connection with the training programs including refilling of the used extinguishers.

c. **Fire Blankets and Rescue Equipment**

Fire blankets and further rescue equipment like first aid kits, stretchers, etc shall be provided as required.

7. **Pressure Reducing Valves For Hose Reel Supply**

Angle globe pattern, single seated, hydraulically operated pilot controlled, diaphragm type, normally open valve of cast iron construction with flanged ends; UL listed for Fire Protection Services. The trim and pilot assembly shall be of brass/bronze/stainless steel and pressure setting shall be made with a single screw, housed in a screwed on, sealable housing. Wetted areas of the valve body shall be epoxy coated. The assembly shall be complete with shut off valves, strainer, pressure gauges, size adjustment spools etc.

Ref : Claval 90 A - 21 or approved equal.

8. a. **Automatic Air Relief Valves**

Bronze body with non-ferrous float and internal working parts. Construction shall be taken apart type for easy maintenance. Outlet shall be tapped for connection to drain line.
Ref : Amtrol 706 or approved equal.

b. **Automatic Ball Drip**
All bronze construction with male threaded inlet and female threaded outlet.

Ref : Gem model F 1687 / Elkhart No. 701 or 702.

9. **Foam Water System**

The foam extinguishing system shall be provided for Diesel Generator set room and the Diesel fuel storage tanks as described in Clause 12.

a. General:

Design, furnish and install a complete FOAM System as described herein as shown on the drawings to be wired, connected, and left in first class operating condition. This system shall include a foam control panel, manual call point, automatic-fire detections, evacuation sounders, alarm bells, flash lights, connections to device, outlet boxes, junction boxes and all other necessary material for complete operating system.

b. Scope and Related Documents

(i) The work covered by this section of the specifications includes the furnishing of all labour, equipment, materials in

connection with the installation of the Foam system as shown on the drawings and as herein specified.

(ii) The complete installation is to conform to the applicable sections of NFPA, Kuwait Fire Brigade and National Electrical Code.

(iii) The entire installed system and all integrated system and system operations shall be within the guidelines of the SBCCI standard Building Code.

(iv) The work covered by this section of specifications is to be coordinated with Fire Alarm System.

(v) Additionally, Foam water system to be provided shall be governed by the following:

* The foam water system shall be provided for the Diesel Generator set engine room, diesel storage tanks & bund around the tanks.

* The system shall be designed as per NFPA-11 and the principle of foam proportioning shall be through in-line foam inductor as shown on the drawings.

* The foam system shall be actuated by means of a deluge valve opening. The water in the pipework shall pickup foam concentrate with the aid of an inductor. The mixture shall flow to the sprinklers and expand into foam. The sprinklers shall distribute foam evenly throughout the protected area.

* The foam quantity shall be based on 3% foam concentrate mixed with 97% of water with a minimum expansion 10 times the volume of foam water solution. The protected area shall be the total plan area within the protected area.

* Hydraulic calculations shall be submitted.

The foam discharge density and period for various areas shall be as follows:

Area	Foam Discharge Density	Time
a. Engine room	6.5 lit/m²/minute	10 min
b. Diesel oil tanks	4.1 lit/m²/minute	30 min
c. Bund protection	6.5 lit/m²/minute	30 min
d. Fuel pump room	6.5 it/m²/minute	30 min

* The foam system shall be designed for automatic operation. For this purpose, suitable heat detectors and alarm equipment shall be provided, as specified elsewhere herein.

* The common foam concrete tank shall be sized for maximum period operation, which is 30 minutes, and for maximum required application for dyke. The foam concrete tank will be common for all required foam protection applications.
* The foam offered shall be 3% AFFF foam concentrate.
* The system design, equipment, calculations, etc. shall be approved by Engineer / KFD before procurement and erection.
* The Contractor shall submit complete technical particulars of each equipment of the system quoted.

c. **Products**

(i) Foam System control panel

- Where shown on the plans, provide and install foam system control panel. Construction shall be modular with solid state and microprocessor based. It shall display only those primary controls and displays essential to operation during a fire alarm condition.
- The system control panels and peripheral devices shall be the standard product of a single manufacturer and shall be designed to meet NFPA, KFD standards.
- Basically the multi area system consists of the following:
  * System power supply
  * Microprocessor based control system
  * General annunciator functions
  * Boards for the combination of the detection and extinguishing.
  * Buzzer for fault indication
  * System status indication
- The system shall execute the following on receipt of the signal from the optic detectors in the engine room or heat detector in the service tank room
  * Sound general fire alarm
  * Shut down interlocked equipment
  * Activate building fire alarm system
- On receipt of the signal from the generator building heat detectors above the generator the system shall perform

* Sound evacuation alarm
* Initiates discharge time delay
* Indicate cylinder circuits at the end of time delay

- Similarly on receipt of signal from heat detectors above the diesel oil storage tanks or from the UVIR detectors from dyke area or from the heat detectors in fuel pump room, the system shall perform
  * Sound evacuation alarm
  * Initiates discharge time delay
  * Activate foam discharge at the end of the time delay

(ii) Power Supply Unit

- The system shall receive 240 VAC power supply through a junction box.
- The system shall have a solid state rectifier for 24V DC output to provide 12 hours standby power and one hour of full alarm power, and shall have an indicator for battery connected.

(iii) Detection Device

- Smoke Detector

  Optic type smoke detector protected against ingress of dust and dirt, suitable for use in areas with high wind velocity, operating temperature –10°C to 50°C and humidity 95% RH. The detachable base shall have indication for fire conditions and facility for connecting to remote indications.

- Heat Detectors

  The heat detector shall be of fixed temperature type for the same service as smoke detector. All electronic circuits shall be solid state devices and virtually hermetically sealed to prevent their operation from being impaired by dust, dirt or humidity.

- Manual call point

  The manual call point shall be electrically compatible with the standard range of automatic detectors so that it can be connected directly into a supervised two wire zone of the manufacturer's standard range of control units. The manual call point shall consist of the base plate, insert and cover and shall be designed for fail-safe operation. The call point shall have a built-in lamp, automatically conforming it's actuating. It shall be possible to test the call point without destroying the seal

or removing the cover and the cover shall be yellow in colour.

- Evacuation Sounder

  The sounder shall be used which produce continuous distinctive sounds and shall be installed at a suitable location.

- Alarm Bell

  Alarm bell shall be under dome type of 6 inches size. The unit shall be mounted inside the room at 220cm above finished floor level. On receipt of signal from first circuit the bell will sound.

- Flash Light

  Flash light is installed in the main exit of the generator room

(iv) **The mechanical components of Foam system shall be**

- **Foam Inductor**

  Provide inline inductors suitable for the required water/foam concentrate capacities with pressure drop not exceeding 35% of inlet pressure. Inductor shall be complete with quick coupling and dip tube all as ANSUL inductors or equal and approved.

- **Foam Sprinklers**

  Provide self-aspirating type foam sprinklers as ANSUL or equal and approved.

- **Deluge Valve**

  Provide quick opening valve of size shown on drawings, or as determined by the system calculations complete with all necessary trims, i.e. pressure gauges, flow meter, control valve solenoid valve, test and drain valve, drip drain, alarm gong, etc. The valve body and cover shall be of cast iron, clapper and clamp ring of bronze, seat rubber of neoprene and screws of steel. The valve shall be as VIKING / ANSUL, or other equal and approved.

- **Foam Concentrate**

  The Contractor shall provide Aqueous Film Forming Foam (AFFF) suitable for the designed system. Foam concentrate to be stored in a suitable container as approved by the Engineer. Provide sufficient concentrate, sufficient for one application, as a standby reserve. Provide sufficient concentrate in addition to the reserve for testing and commissioning the system.

- **Solenoid Control Valve**

  The solenoid control valve shall comprise of a flanged cast iron valve body with stainless steel trim, normally closed with a 24 V DC solenoid to give drip tight seal when de-energised, normal over-ride control, flow clean strainer and opening and closing speed controls.

(v) **Installation**

The Contractor shall provide and install the system in accordance with the plans and specifications, all applicable codes and the manufacturer's recommendations. All wiring shall be installed in strict compliance with all the provisions of MEW requirements and NEC. Upon completion, the Contractor shall so certify in writing to the Engineer.

All devices shall be wired with PVC cable of 1.5mm² size.

d. **Pillar Hydrants (outdoor hydrants)**

1. Bronze fitted / ductile with 150mm (6 inch) nom. dia. flanged inlet horizontally split barrel with threaded break away ring, 100mm (4 inch) nom. dia. Main valve and automatic drain valve flanged barrel cover; operating nut as used by Kuwait Fire Brigade; one no. 100mm (4 inch) nom. dia. Pumper connection and two nos. 65mm 2½ inch) nom. dia. Bib nose landing valves with instantaneous female outlets and cap and chain; duck foot bend etc.
2. Epoxy coating of minimum 150 microns thickness shall be given to all of the wetted internal surfaces and buried external surfaces and lacquer primer and fire red enamel coating to the exposed surface.
3. Furnish 3 nos. operating keys for the contract. Ref: Bayard or approved equal.

10. **Deluge Water System**

The deluge system will be designed and provided for the transformers in the transformer room.

a. 1. General: Design, furnish and install a complete deluge system as described herein and as shown on the plans, to be wired, connected, and left in first class operating condition. This system shall include a deluge control panel, manual call point, automatic fire detections, evacuation sounders, alarm bells, flash lights, connections to device, outlet boxes, junction boxes and all other necessary material for complete operating system.

b. Scope and Related Documents

1. The work covered by this section of the specifications includes the furnishing of all labour, equipment, materials in connection with the installation of the deluge system as shown on the drawings and as herein specified.
2. The complete installation is to conform to the applicable sections of NFPA, KFB and National Electrical Code.
3. The entire installed system and all integrated system and system operations shall be within the guide lines of the SBCCI standards building Code.
4. The work covered by this section of specifications is to be coordinated with Fire Alarm System as under Section 16721, Division 16 for Electrical Works.
5. Additionally, deluge water to be provided shall be governed by the following:

Deluge System

Independent deluge valves will be provided for spray nozzle pipe work of the three transformers.

i) The system shall be designed as NFPA-15 guidelines.

ii) Hydraulic calculations shall be submitted.

iii) The system design, equipment, calculations, etc. shall be approved by the Engineer / KFB before procurement and installation.

iv) The Contractor shall submit complete technical particulars of each item of equipment of the system.

c. **Products**

1. **Deluge system control panel**

i) Where shown on the Drawings, provide and install deluge system control panel. Construction shall be modular with solid state and microprocessor based. It shall display only those primary controls and displays essential to operation during a fire alarm condition.

ii) The system control panels and peripheral devices shall be the standard product of a single manufacturer and shall be designed to meet NFPA, KFD standards.

iii) Basically the system consists of the following:

- System power supply
- Microprocessor based control system
- General annunciator functions
- Boards for the combination of the detection and extinguishing

- Buzzer for fault indication
- System status indication

2. **Power Supply Unit**

i) The system shall receive 240 VAC power via a lockable isolator switch fuse rated for 15 amps.

ii) The system shall have a solid state rectifier for 24V DC output to provide 12 hours standby power and one hour of full alarm power, and shall have an indicator for battery connected.

3. **Detection Device**

i) Optical type smoke detector protected against ingress of dust and dirt, suitable for use in areas with high wind velocity, operating temperature 10°C to 50°C and humidity 95% RH. The detachable base shall have indication for fire conditions and facility for connecting to remote indications.

ii) Heat Detectors

The heat detector shall be fixed temperature type of the same service as smoke detector. All electronic circuits shall be solid state devices and virtually hermetically sealed to prevent their operation from being impaired by dust, dirt or humidity.

iii) Manual call point

The manual call point shall be electrically compatible with the standard range of automatic detectors so that it can be connected directly into a supervised two wire zone of the manufacturers standard range of control units. The manual call point shall consists of the base plate, insert and cover and shall be designed for fail safe operation. The call point shall have a built-in lamp, automatically conforming its actuating. It shall be possible to test the call point without destroying the seal or removing the cover and the cover shall be yellow in colour.

iv) Evacuation Sounder

The sounder shall be used which produce continuous distinctive sounds and shall be installed at a suitable location.

v) Alarm bell

Alarm bell shall be under dome type of 6 inches size. The unit shall be mounted inside the room at 220cm

above finished floor level. On receipt of signal from first circuit the bell will sound.

vi) Flash light

Flash light is installed in the main exit of the transformer room.

4. i) **Deluge Valve**

Provide quick opening valve of size shown on drawings, or as determined by the system calculations complete with all necessary trims, i.e., pressure gauges, flow meter, control valve solenoid valve, test and drain valve, drip drain, alarm gong, etc. The valve body and cover shall be of cast iron, clapper and clamp ring of bronze, seat rubber of neoprene and screws of steel. The valve shall be as Viking / Ansul or other equal and approved.

ii) **Solenoid Control Valve**

The solenoid control valve shall comprise of a flanged cast iron valve body with stainless steel trim, normally closed with a 24V DC solenoid to give drip tight seal when de-energized, normal over-ride control, flow clean strainer and opening and closing speed control.

5. i) **Installation**

- Provide and install the system in accordance with the Drawings and specifications, all applicable codes and the manufacturer's recommendations. All wiring shall be installed in strict compliance with all the provisions of MEW requirements and NEC. Upon completion the Contractor shall so certify in writing to the Engineer.
- All devices shall be wired with PVC cable of 1.5mm^2 size.
- Installation of equipment and devices that pertain to other Work shall be closely coordinated with the electrical services.
- The manufacturers authorized representative shall provide onsite supervision of installation.

ii) **Testing**

- The completed fire alarm system shall be fully tested in accordance with NFPA by the Contractor in the presence of the Engineer and the KFD officers. Upon completion of a successful test, the Contractor shall so certify in writing to the Engineer.
- The system and the equipment and products shall be as manufactured by Simplex-USA, Tann

Synchronome-UK, Siemens-Germany, Cerberus-Switzerland, Thorn Security-UK.

iii) **Warranty**

- The equipment Contractor shall arrange with the manufacturer an extendable maintenance contract to provide a minimum of two (2) inspections and tests per year in compliance with NFPA guidelines.

11. Fire Pumps and Accessories

a. Work Included

1. Fire pumps
2. Pressure maintenance (Jockey) Pump(s)
3. Pump Controllers
4. Fire Pump Accessories
5. Electrical Works in connection with Fire Pumps

b. References

1. NFPA20 - Automatic Fire Pumps and Controllers
2. NFPA 71- National Electrical Code
3. IEE - Regulations for Electrical Installation in Buildings

c. Quality Assurance

1. The requirements of the following organisations shall be conformed with, as appropriate:

i) Kuwait Fire Department (KFD)

ii) NFPA 20 in respect of Fire Pumps and Controllers. Additional requirements, if stated. Fire pumps and controllers shall be listed by Under writers Laboratories (U.L.) & Factory Mutual Testing Laboratories (FM) for Fire Protection services.

iii) Equipment supplied shall have local suppliers/representatives.

d. Submittals

1. Product data, certified pump performance characteristics, with selection plotted, manufacturer's assembly drawings and data on equipment dimensions, service connections, operating weights etc.
2. Characteristics such as full load starting kVA, power factor and current, full load running current and power factor etc. shall be submitted.
3. Wiring diagrams, details of components and panel construction and mounting details shall be submitted in respect of control panels.

4. Listing / certification from U.L. / FM in respect of fire pumps that the assembly construction and performance equals or exceeds NFPA 20 requirements shall be submitted.

e. **Delivery, Storage and Handling**

1. Weatherproof covering shall be retained on pumps and controllers until commissioning.

f. **Acceptable Manufacturers**

1. Fire Pumps
   i) ITT A-C, USA
   ii) S.P.P., UK
   iii) Peerless, USA
   iv) Patterson , USA
   v) or approved alternatives
2. Jockey Pumps
   i) Grundfos, Denmark
   ii) Worthington, UK
   iii) KSB, Germany
   iv) or approved alternatives
3. Pump Controllers
   i) S.P.P., UK
   ii) Firetrol, UK
   iii) Metron, USA
   iv) or approved alternatives
4. Components such as fuses, contactor(s), indicators, timers, etc. which may require replacement in future, shall be products of the same standard / manufacture as that of the electrical Works.

g. **Electrical Motor Driven Fire Pump(s) (FM listed)**

1. Type: Coupled, horizontal split case, single stage centrifugal type, speed limited to maximum 3000 RPM.
2. Material of Construction:

   Impeller …… Bronze

   Shaft ……. Stainless Steel

   Casing ……..... Cast / Ductile iron

   Case wearing ring …. Bronze

   Seal …… Packing

Base plate …….. Cast iron / fabricated steel

3. Accessories : Air bleed off valve, compound gauge at suction and pressure gauge at discharge, casing pressure relief valve and flexible connections at suction and discharge.
4. Working Pressure: Pump casing and flanges shall be suitable for a working water pressure of 1724 kPa (250 psig) working water pressure at 121°C (250°F).
5. Capacity : Nominal flow and pressure ratings shall be in general with the schedules on the Drawings confirmed by the Contractor and approved by the Engineer. Pumps shall have name plates stating the parameters, permanently attached to the casing.
6. Electrical Motor : Type and construction shall be as follows:

   Type ……Squirrel cage induction, delta wound.

   Enclosure …….. TEFC (IP 44)

   Service factor …… 1.15

   Power factor …….. 0.85 minimum at full load

   Insulation …… Class F

   Temperature rise …… Class B

   Electrical supply …….. 415 v / 3 Ø / 50 Hz

7. Motor Power Rating: Motor power rating shall be as given in the schedules on Drawings. The motor shall be rated for continuous operation at 150% of the pump nominal flow. Additional capacity available from motor service factors exceeding unity may be used in working out the motor power ratings in limiting cases. The motor acceleration period (star to delta charge over) shall not exceed 10 seconds.

h. **Jockey Pump(s)**

1. Type : Vertical, multistage centrifugal type of 2950 rpm speed.
2. Materials of Construction: Multistage centrifugal pumps.

   Impeller …….. Stainless steel

   Shaft ……Stainless steel

   Stage housing ……..Stainless steel

   End housing …… Cast iron

   Seal ……..Mechanical

3. Accessories: Compound gauge at suction and pressure gauge at discharge and flexible connections at suction and discharge.
4. Working Pressure: Pump casing and connections (threaded / flanged as appropriate) shall be suitable for a working water pressure of 250 psig / working water pressure at 121°C (250°C).
5. Capacity: Nominal flow and pressure ratings shall be as given in the schedules on Drawings. Pumps shall have name plates stating these parameters, permanently attached to the casing.
6. Electrical Motor: Type and construction shall be as follows:

   Type ……. Squirrel cage induction, delta wound

   Enclosure …….. TEFC (IP44).

   Power factor ……. 85% minimum at full load

   Insulation …….. Class F

   Temp. rise ……. Class B

   Elec. Supply…….415 v / 3 Ø / 50 Hz
7. Motor Power Rating: Motor ratings shall be as given in the schedules on Drawings. However, the motor shall not be overloaded at any point of the pump performance curve.

i. **Controllers for Motor Driven Fire Pump (UL & FM listed)**

1. The controller shall be of the combined manual and automatic type suitable for star (Wye) delta starting at 415 v / 3 Ø / 50 Hz supply. Refer to schedules on Drawings for power ratings. The panel components/ functions shall be as listed below:
   i) Main isolator switch (4 pole) and circuit breaker combination, mechanically interlocked to operate with a single, flange mounted external handle. The interlocking shall be such that the circuit breaker (with minimum 22 kAmps rupturing capacity) will engage or break the load current. Both of the above shall be suitable for padlocking in ON or OFF position and shall be interlocked with the panel door, restricting access to the controller with the switch in 'ON' position, except by a hidden tool operator defeater. Provide external emergency release for the circuit breaker.
   ii) Audio visual earth leakage alarm.

iii) Power on (supply healthy) indicator wired through normally closed contacts of the power available relays to give true indication. Loss of power in any one phase shall cause the available relays to give true indication. Loss of power in any one phase shall cause the light to go off.

iv) Control circuit healthy indicator.

v) Pump on demand indicator.

vi) Pump run indicator.

vii) Manual, pump start and stop push buttons.

viii) Emergency start lever with latch.

ix) Adjustable star to delta change over timer (consult motor manufacturer for change over timing).

x) Adjustable, 10-300 psi, combination pressure gauge switch, mounted on the enclosure flange. Extend piping to outside of the panel with union. Pressure switch shall be wired for automatic start only.

xi) Starter contactor with auxiliary relays.

xii) Fused control power circuit, with voltage not exceeding 240 v/ 1 Ø / 50Hz. Use transformers where appropriate.

xiii) Interlock between duty and standby pumps, allowing the operation of only one pump at a time.

xiv) Terminal block for interlocking wiring.

xv) Earthing bar for equipotential bonding.

xvi) Set of terminals / relays with volt free contacts for connecting to building automation system and remote alarm panel.

j. **Remote Alarm Panels**

1. Remote alarm panels shall be complete with 24 hours standby batter pack, battery charger, alarm bell mute pushbutton etc. to indicate the following:

i) Supervisory voltage normal

ii) Pump 1 phase failure

iii) Pump 2 phase failure

iv) Pump 1 on demand

v) Pump 2 on demand

vi) Pump 1 running

vii) Pump 2 running

k. **Jockey Pump Starter(s)**

1. This starter shall be of the combined manual and automatic type, suitable for direct-on-line (DOL) starting at 415 v / 3 Ø / 50 Hz supply. Refer to schedules on drawings for power ratings. The panel components / functions shall be as listed below:

i) Mains isolator switch (4 pole) with power on indicator.

ii) DOL starter contactor with overload trip and set of fuses.

iii) Hand/ off / automatic selector switch.

iv) Pump run and trip indicators with audible alarm for trip.

v) Adjustable, 10 to 300 psig, combination pressure gauge-switch, mounted on the enclosure flange. Extend piping to outside of the panel with union. Pressure switch shall be wired for automatic start and stop of the pump.

vi) Start / stop push buttons.

vii) Adjustable minimum run timer with 0 to 6 minutes range.

viii) Fused control power circuit, with voltage not exceeding 240v / 1 Ø / 50Hz.

ix) Earthing bar for equipotential bonding.

l. **Pressure Relief Valves**

1. Cast iron body with bronze trim, angle pattern, pilot operated diaphragm valve. The valve shall be rated Class 125, factory preset at 7.5 bars (110 psig) and shall be bypass (to pump suction) type. Provide pressure gauge with unit.

2. For high pressure pumps, similar to the above, rated class 250 with discharge to atmosphere, factory pressure at 12.9 bars (190 psig).

m. **Flowmeter(s)**

1. Cast steel venturi meters, rated for 250 psig working water pressure, with flanged ends, fixed flowmeters calibrated in us gpm (range – 200% of pump flow), shut off and bleed cocks, colour coded connection house etc. complete.

n. **Suction Strainers**

1. Food grade epoxy coated cast iron body with integral flange and 12mm (½") perforations.
2. Fasteners shall be corrosion resistant materials like stainless steel or brass.

3.PART 3 – EXECUTION:

3.1 GENERAL

A. The Contractor shall coordinate the Shop Drawings and the execution of the work of other trades.

B. The Contractor shall ensure that the work is compatible with the architectural finishes prior to placing orders, fabrication and installation.

C. Information as may be required by MEW, for obtaining approvals, shall be furnished.

D. The timely placement of sleeves, inserts and the like shall be ensured.

E. Composite shop drawings shall be prepared, to a suitable scale, showing how the work is installed in relation to the work of other trades.

F. The sufficiency of dimensions of plant areas, door ways etc. and suitability of slabs and other structural members for placements, operation and maintenance of equipment shall be ensured.

3.2 PREPARATION

A. Pipes and tubes shall be cut perpendicular to the axis with approved cutting tools, the ends reamed and burrs removed.

B. Scale and dirt, on inside and outside and weld splatter shall be removed before assembly.

C. The coating on ductile iron and Galvanised iron pipes and fittings shall be repaired with approved paint (recommended by the manufacturer) where factory coating has been damaged.

D. Piping connections to equipment shall be made with flanges or unions.

3.3 SPACING AND LOCATION

A. Piping shall be installed in such a way that conserves building space and not interfering with the use of space.

B. Exposed piping shall be installed parallel or at right angles to the building wall, except where otherwise shown on the Drawings.

C. Minimum clearances shall be provided around piping.

D. Adequate clearance shall be provided for the installation of insulation and access to valves and fittings.

E. Piping shall be grouped at common elevations, wherever possible.

F. Piping shall be installed in such a way that allows for expansion and contraction without stressing pipe joints or connected equipment, by providing swing joints, offsets, expansion joints etc. wherever necessary as instructed by Engineers.

G. Access doors shall be provided where valves and fittings are not exposed. Size and location of access doors shall be as indicated on the Drawings and/ or approved by the Engineer.

3.4 PIPE FITTINGS

A. Tapered reducer fittings shall be installed where changes in pipe sizes occur. The use of site fabricated fittings or bushings shall not be permitted.

B. Tapered, factory manufactured reducer fittings (eccentric type at suction and concentric type at discharge) shall be installed at pump connections. Eccentric reducer fittings shall be installed with level crown.

C. Factory manufactured fittings shall be installed where changes in pipe direction occur. Bending or forming of piping shall not be permitted without the written permission of the Engineer.

D. Connections shall not be made between piping of different services, under any circumstances. The existence of any one such connection in the Works, whether temporary or permanent, shall make the Contractor liable for an anti-confusion test for all of the concerned services.

3.5 SLOPES AND INVERTS

A. Fire water piping shall be sloped toward the main riser and arranged to drain at the nearest floor drain assemblies. The additional drain valves / automatic ball drips shall be provided at undrainable segments of the piping and their discharge shall be piped to a convenient location.

B. Buried piping, outside the building, shall be established to ensure not less than 1200mm of cover, especially in areas subject to traffic loading.

3.6 THREADS AND SEALANTS

A. Full depth threads shall be cut on prepared pipe ends, preferably using power driven machines using cutting fluids. The threads shall be cleaned thoroughly before applying thread sealant.

B. Teflon thread sealing tapes or hard setting, non-toxic sealing compounds shall be used on the male thread (only) before making joints. Joints opened for repairs shall be brushed clean and given fresh sealing tape or compound.

3.7 VALVES

A. Valves shall be installed with stem upright or horizontal, not inverted; except with the written permission of the Engineer, for each location.

B. Valves shall be of same size as pipeline, except where shown otherwise on the Drawings.

C. Valves with flanged ends shall be used in valve pits and when directly buried, irrespective of size.

D. Gate valves shall be used for shutoff and to isolate equipment, part of systems or risers.

E. Drain valves shall be installed at system low points and at the foot of risers

F. Appropriate valve gland packing, sealing and gasket materials shall be selected for the temperature and pressure encountered.

G. In line flap type check valves shall be provided on Fire Brigade Breaching Line.

3.8 UNIONS AND FLANGES

A. Flanges / unions shall be provided on horizontal pressure piping at spacing not exceeding 18.0 m (60 feet).

B. Grooved mechanical couplings and fasteners shall be used only in accessible locations.

C. Unions or flanges shall be installed downstream of the valves and at equipment or apparatus connections.

D. Dielectric unions or flanged fittings shall be based wherever joining dissimilar metals.

3.9PROTECTION DURING CONSTRUCTION

A. Ends of piping shall be kept closed with factory manufactured plugs or blind flanges with integral indicating flags, to prevent the entry of foreign matter, during the progress of the work. Such plugs or flanges shall be removed on completion of the works.

B. The piping shall be blown out using dry compressed air, prior to testing.

3.10 TESTING OF PRESSURIZED PIPING

A. The pipe shall be jointed, plugged and shall have been in position for at least 24 hours, before the tests are carried out.

B. The piping shall be tested for line gradient and water tightness. Labour and necessary testing instruments such as gauges, pumps etc. shall be provided by the Contractor. A minimum of 2 nos. identical pressure gauges shall be installed at the extremities of the piping circuit to be tested.

C. The piping shall be filled with clean fresh water, leaving all high points open to allow for purging of air. A soaking period of at least 24 hours shall be allowed for cement lined pipes.

D. The system shall be pressure tested using manual pumps in increments of 25 percent of the test pressure. A standing period of 10 minutes shall be allowed after each pressure increment. Pressure testing using motor driven pump shall not be permitted.

E. The system shall not be over-pressurized under any circumstances. Calibrated pressure relief valves shall be installed in the tested circuit, if the test pressure is close to the maximum permissible working pressure of any of the system components.

F. Valves and control devices shall be kept in the open position, during the pressure test. After completion of pressure test, valves shall be closed, one at a time, starting from the pressure release end, so as to ensure tightness of the valves.

G. The piping shall be hydrostatically tested to a pressure of 689 Kpa (100 psi) or 1.5 times the system working pressure, whichever is greater, but limited to 200 psi. The pressure shall be maintained for at least 4 hours. The circuit temperature shall be recorded along with the pressure readings and pressure fluctuations due to ambient temperature variations shall be allowed for.

H. Joints shall be checked for leaks by swabbing with a dry tissue. Drop in pressure to the order of 1.5 psi per hour, but without any visible leaks, shall be considered as acceptable.

I. Piping shall be tested in segments during the progress of the work. An official log book shall be maintained for recording the tests carried out on sections of piping, including test pressure, date of test and approval signature of Engineer's representative witnessing the test.

3.11 SYSTEM FLUSHING AND CHARGING

A. The piping shall be flushed with fresh water, intended for fire protection services, after completion of tests. No segment of the piping shall be left partially filled with water at any time, to prevent the occurrence of internal corrosion.

B. The system shall be filled gradually using a pump, after leaving all high points open to purge the air.

3.12 PROTECTIVE PAINTINGS

The Contractor shall paint all exposed and concealed fire protection pipe work, pipe supports, hangers, steel cabinets, etc as follows:

A. Clean and remove scale and rust from all exposed ferrous metal pipework and iron work exposed to view and concealed fire fighting pipework including pipe hangers, etc. Apply a minimum of two coats of approved primer. Apply a minimum of one coat approved undercoat paint and two coats of approved gloss finish paint until sufficient cover is obtained to the satisfaction of the Engineer.

B. Paint all galvanised pipework with an approved etching primer before painting with undercoats and gloss finishing coats as herein specified.

3.13 COLOR CODING

A. Paint all fire protection pipe work Red to BS 4800 ref. 04.E.53.

B. All colour coding shall be in accordance with BS 1710, identification of pipeline.

3.14 FIRE CABINETS

A. Framing of correct size, extending to the plaster finish shall be provided for all recessed fire cabinets. Fire cabinets shall be secured in the wall by screws, at the frame.

B. Base supports fabricated from steel angles shall be provided for taking up the weight of cabinets installed in shaft walls.

C. Openings in fire cabinets shall be cut using appropriate tools. Rubber grommets shall be provided at these openings to prevent rattling and the entry of dust.

D. Boxed sheet metal stiffeners or external supporting steel framing shall be provided for installing hose reels and similar items.

3.15 AUTOMATIC AIR RELEASE VALVES

A. Access doors shall be provided in shaft walls and ceilings where air release valves are installed. The discharge of the valve shall be piped to a convenient location.

3.16 FIRE PUMPS

A. Fire pumps shall be installed in such a manner that avoids horizontal elbows at pump station, excludes an entrapment in suction line and allows unrestrained movement of the pump assembly (for vibration isolation purposes).

B. Required adjustments to pipe sizes shall be made immediately after the pump flanges. Flanged eccentric reducing spool with level crown shall be used at pump suction and concentric type at discharge.

C. Flexible connections shall be installed at the pump suction and discharge to prevent carry over of pump vibrations to system piping. Piping shall be anchored immediately after the flexible connections.

D. The suction header shall be installed horizontally. Foundations for different models of pumps shall be made to suit the suction header, so that all the suction lines are horizontal.

3.17 CONTROL PANELS

A. Panels shall be fabricated from minimum 1.5mm thick sheet steel and shall have continuously welded butt joints. Two coats of red oxide primer and two coats of baked on fire red enamel shall be applied on finished cabinets. All required holes and cut outs shall be done at the factory.

B. Internal wiring shall be done in a neat and professional manner, using cable ties, slip-on spiral plastic bundle sheaths, etc. Ample free lengths shall be provided to allow the full swing of doors.

C. Suitable legs, drilled for bolting down to house keeping pads, shall be provided on control panels.

D. Wall mounted panels shall be stiffened with profiled sections welded to the back plate, as required. Top of wall mounted panels shall be at 1800mm above FFL.

E. Panels shall have enclosures to IP44 as minimum requirement and anti-condensation heaters within.

3.18 CONDUITS, TRUNKING AND CABLE TRAYS

A. Conduits, trunking and cable trays shall comply with Division 16 and Division 18.

B. Conduits shall be fixed to walls / ceilings with two pieces clamps, spaced at not more than 1200mm.

C. Trunking shall be attached to walls by brass screws in plastic expansion plugs.

D. Cable tray hangers shall be attached to ceilings with expansion anchors and studs. Support vertical cable trays by bolting to steel angles extending from floor to ceiling.

E. The general arrangement of power distribution in the fire protection plant room shall be as follows:

1. Rise from ESMSB to a horizontal network of cable trays. Drop to free standing panels in cable trays.
2. Rise from panels to another layer of horizontal network of cable trays. Drop to motors in cable trays.

3.19 FLOW METERS

. Flow meters shall be installed with a minimum straight piping of five (5) diameters upstream and two (2) diameters downstream. The pressure tap-off(s) shall be installed in horizontal position (vertical position prohibited) as far as possible.

3.20 INSPECTION, TESTS AND ADJUSTMENTS OF FIRE PUMPS

A. Prior to start-up:

1. The pump motor assembly alignment shall be checked and adjusted, if necessary. Steel cleats shall be welded on pump and motor bases to lock them in aligned position.
2. Foundation and coupling bolts shall be tightened and locked.
3. Pump shaft shall be checked for free rotation.
4. Electrical continuity and insulation of motor and the control panel shall be checked by meggering.
5. The calibration of the relief valve shall be shut-off and the test line opened.
6. The system isolation valves shall be shut-off and the test line opened.
7. The tripping element of the circuit breaker shall be checked for correct selection and proper installation. The star delta change over timing shall be adjusted to the period recommended by the motor manufacturer.
8. System power supply voltage shall be checked and all other checks outlined in the controller operation manual performed, before energizing the controller.
9. The suction lines and the pump casing shall be checked for proper filling with water.

B. The following shall be executed to start the system up:

1. The direction of rotation of the pump shall be checked and corrected, if necessary, by momentary operation of the emergency start lever.
2. The valve of the test line shall be partially closed to avoid the operation of the pump at high discharge rates.
3. The pump shall be started on manual mode.
4. The motor full load current shall be checked by manipulating the flow.
5. The pressure relief valve shall be checked for proper operation by gradually closing the tests level.
6. The pump and motor bearings shall be checked for signs of overheating.
7. The suction line shall be checked for signs of entry of air and proper suction intake flow.

C. The pump performance shall be verified as follows:

1. The pump head shall be checked at 100% and 150% of nominal flow and conformity with design requirements verified.
2. The pump shall be stopped by closing the test line. The system pressure shall be released gradually by opening the test valve and the pressure switch setting shall be adjusted for automatic cut-in. The pressure switch settings for automatic cut-in and cut-out shall be adjusted for the jockey pump in a similar manner.
3. Statement of compliance shall be submitted in respect of pumps, piping and controls; in the form to be approved by the Engineer in all respects along with pump performance curves with the test data plotted, prior to Completion.

D. The following shall be executed to put the system into services:

1. Isolate the fire pump controllers.
2. Close the test line and open the system isolating valve. Ensure that the system outlets are closed.
3. Fill the system with the jockey pump. Maintain pressure for 24 hours and ensure that there are no leaks.
4. Energize fire pump controllers and ensure that the system is automatic mode.

3.21 GUARANTEES AND WARRANTIES

A. The Employer shall be furnished with the manufacturers guarantees and warranty certificates, duly registered with the manufacturer.

END OF SECTION

SECTION 4G.5
OVERHEAD CRANE

1. **General:**

The Specifications hereunder are brief and herefore the contractor shall include all equipment, materials, labour etc. for the complete installation to ensure best workmanship and operating conditions, whether detailed hereunder or not. The maintenance guarantee period shall be two years from the date of taking over.

2. **Scope**:
The contractor shall supply and install overhead cranes as per speciications and bill of quantity.

3. **Qualification of Sub-Contractor**:

The equipment shall be installed by a reputed sub-contractor with at least 5 years experience in the field and should have executed for at least two similar projects in Kuwait. A Sub-contractor who is also the authorized agent of the equipment being offered, will be prefered to other subcontractors who are not authorized agents. However all the equipment being offered shall have an authorized reputed local agent, who shall guarantee the availability of spare parts for a period of at least 15 years. A certificate of this effect shall be submitted along with the offer.

4. **Electric Overhead Travelling Crane:**

Technical Specification

The overhead crane shall be from a reputable manufacturer and shall be of the double girder/single girder, with electric hoist and travel motors suitable for both longitudinal and cross travelling to cover the whole area of the served place with long and cross travel speeds not exceeding **32m/min.** However, long travel speed should consist of slow and fast speeds of 8/32 m./min. and cross travel of 4/16 m. /min. The crane shall in general comply with BS 466:1984 and to FEM or any other equivalent standard. Tenderer must examine the civil drawings to give the exact dimension of the span and to make sure that the load clearance and the depth of the

columns supporting the crane tracks are sufficient. The crane shall be installed in strict accordance to the manufacturer's instructions and approval of the engineer.

The functional lines of double girder electric overhead traveling crane should harmonize perfectly with the architecture of the place where it is going to be used as shown on drawing. The structure of the crane shall be designed and constructed so that when it is being working under service conditions the stress in any part shall not exceed the permissible stresses stipulated in BS 2573. The duty of the crane shall be 'medium', i.e. Class-2 in accordance with BS 2573.

The crane tracks shall be correctly positioned on suitable well aligned girders for smooth running of the crane and the tolerance of the tracks should not exceed the limits recommended by the crane manufacturer.

The main girders shall be of box-type construction incorporating diaphragm plates.

The vertical deflection caused by the safe working load and the weight of the crab in the central position shall not exceed 1/900 of the span.

End carriages shall be fabricated from rolled steel sections stiffened internally throughout its length overall welded together to produce a box section of high torsional resistance or shall be of cast steel construction. High tensile steel bolts, shall be used for connecting end carriages and crane girders. The end carriages shall be fitted with substantial safety stops to prevent the crane from falling more than one inch in the event of breakage of a track wheel, bogie or axle. Steel wheels or steel-tired wheels shall be provided. Wheels shall be of the double-flanged type with the tread and flanges machined accurately to size and the flanges tapered and reduced.

Care shall be taken to ensure that rail wheels are in alignment with each other and that the wheels in each end carriage are parallel. The end carriages shall be provided with four rubber buffers (end stops) on the end carriage cover plates.

The crab shall have low dead weight and small overall dimensions, crab frames shall be fabricated from rolled steel sections and plates riveted, bolted or welded together or shall be of cast steel construction. The crab shall run on rails mounted on the girders. End stops on both sides shall be provided to prevent it from over running. The travel wheels shall run on anti-friction bearings lubricated for life. The crab shall include an electric hoist able to sustain loads in absolute safety. A brake shall be provided and is so connected that it is automatically applied whenever the hoist motor is broken, the controller is released or due to power failure to arrest the motion and hold at rest any load up to and including the test load at any position of the life.

A crane speed unit shall be provided with the electric hoist for slow movement of load when required by the operator. Hoisting rope shall be in accordance with BS 302 and 621. The specified nominal breaking strength of the hoisting rope shall be not less than eight times the safe working load thereon.

Rope drum shall be sufficiently wide to accommodate in one layer the length of rope required for the specified lift, and in addition not lower than three dead turns at anchored end, and one spare groove at the opposite end. Rope anchorages shall be readily accessible.

The crane shall be controlled from the floor through a push button pendant, which can travel independently of the crab along Crane Bridge. Effective guarding shall be provided for revolving shafts, couplings, gear wheels and pinions where practicable.

Rope pulley, guarding, lifting hooks and shackles to be in accordance with section three of BS 466:1984.

Limit switches for all motion should be provided. The switch mechanism should be positive in action, completely automatic and self-resorting.

Testing of the crane shall be carried out in accordance with section five of BS 466:1984 (provide all testing apparatus and equipment, including weights, to perform the required tests.

The proposed crane should have a local established agent in Kuwait.

END OF SECTION