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WATER SUPPLIES FOR FIRE SERVICES – V1

In 2015 it will be 25 years since the advent of the Building Code of Australia (BCA) in 1990 and during that time I have been providing advice, system designs and fire engineering for many buildings and structures. A representative selection of buildings is listed in my "Work Narrative" on my web site http://fscs-techtalk.com.

Since 1992, these services have been provided under the banner of ***Fire and Security Consulting Services*** (FSCS) based in Queensland. During this latter period FSCS has frequently been asked to review building designs prior to establishing a basis for developing Alternative Solutions.

Invariably it has been found that the building designs fail to make provision (explicit and / or spatial) for fire services such as fire water storage tanks, pump rooms, power supplies, ventilation and fire services access.

Design and Construct (D & C) contracts are invariably the main culprits and it is usually impossible for the Client to be certain that the selected Contractor has included for the legislated features and systems in their tender.

Accordingly this paper, based on many years' of observations, is formulated to provide advice to Clients, Developers, Architects, Consulting Engineers and Builders so that at the building approval stage, time delays, cost overruns and subsequent "finger pointing" is avoided.

This paper based on the 2014 edition of the BCA , concentrates on multi-storey Class 2, 3 and 5 buildings with associated Class 7a car parks and minor Class 6 retail occupancies because this mix of occupancies is predominant in Queensland. Note that the BCA advises that minor Class 6 (shops) occupancies need not be considered separately provided that they are part of and not less than 10% of the predominant Classification. This makes it easy for office and residential buildings to have small gift shops / cafes etc. located on the Ground Floor without fire separation from an entrance lobby.

For the purposes of these guidelines it is not possible to cover Class 7b, 8 and 9 together with large Class 6 occupancies which pose increased complexity. However specific advice is available from FSCS for these types of developments. The FSCS web site **http://fscs-techtalk.com** a number of papers covering design features in these occupancies.

This paper is sectioned in the order that I believe has the most impact on the design, with advice to the Architect being the primary aim. Note however that this paper does NOT purport to replace the BCA or relevant Australian Standards and it is important that the Services Consultants, as well as the Architect, be fully conversant with the BCA. It is too late and costly for the design team to rely on the Building Certifier to do their work. Often, with inexperienced Architects or Building Designers, the engagement of a BCA Consultant at a very early stage of design has advantages.

Note that in this paper words printed in ***italic bold*** have a specific meaning and are defined in the BCA

1 - BUILDING CODE OF AUSTRALIA

The BCA forms the prescriptive and performance requirements for fire services in a building and advises that if a design meets the Performance Requirements, then the prescriptive or "Deemed to Satisfy" (DtS) requirements are met.

The BCA references a number of Australian Standards, the relevant ones for this paper are listed below. The design of the fire services and the provision for space and facilities within the building is based on these Standards and whilst Hydraulic, Mechanical and Electrical Consultants are responsible for the detailed design of the fire services, FSCS considers it imperative that the Architect has a good understanding of the design isssues. A building design that does not address the system requirements can result in significant cost and time overruns.

The BCA allows Alternative Solutions to be developed using a "Fire Engineering" process when or where the prescriptive BCA requirements cannot be met. The process assesses the proposed building design to address compliance with the Performance Requirements of the BCA or compares the proposed building with a comparable DtS building.

The process for Alternative Solutions can be costly with fees for the Fire Engineer, Building Certifier and Queensland Fire and Emergency Service (QFES) Building Approval Officers.

The use of Alternative Solutions as a cost saving measure is discouraged by the Regulatory Authorities

2 - AUSTRALIAN STANDARDS

The Australian Standards related to the fire services design include the following. These Standards contain critical design data addressing location and spatial requirements that the Architect or Consultant must make provision for. :-

- *AS/NZS 1680.2.2 – Interior and workplace lighting*
- *AS2118.1 – Automatic fire sprinkler systems. Part 1: General requirements*.
- *AS/NZS2293 – Emergency luminaires and exit signs. Part 1 - System design, installation and operation*
- *AS2304 2011 – Water Storage Tanks for Fire protection Systems*
- *AS2419.1 – Fire hydrant installations. Part 1: System design, installation and commissioning.*
- *AS2441 – Installation of fire hose reels*.
- *AS2941 – Fixed Fire protection Installations – pumpset systems*.

Note that the Standards current and listed in the BCA. 2014 are those to be used. This paper uses those Standards referenced in BCA 2014.

3 - WATER SUPPLIES

As well as domestic use, water supplies for buildings are required to serve required fire protection systems which include fire hose reels, fire hydrants and automatic fire sprinkler systems.

Every building with a ***required*** water based fire protection system will require space either within or outside the building to house the equipment associated with the system. Typically they include the following:-

- Fire pump room; and
- Fire water tank(s); and
- Fire Brigade Booster enclosure; and
- Fire sprinkler control valve enclosure; and
- Fire Indicator Panel (FIP) location.

And for high rise buildings, either a ***fire control centre*** or ***fire control room***.

The provision of these facilities falls within the Architect's remit and this paper is designed to provide sufficient advice as what is required. Fire protection water supplies are sourced from the municipal reticulated water supply and to be consistent with the relevant Australian Standards, hereinafter called the town main. A connection from the town main supplies, either directly or by means of on site storage tanks, systems. Note that where storage tanks are provided, one or more pumps are installed.

The fire hose reel, fire hydrant and fire sprinkler systems require specified (by reference to the relevant Australian Standard), water flow rates and pressures. Flow rates are specified as either litres per second (l/s) or litres per minute (l/m), either can be used. Pressures are quantified as kilopascals (kPa) or metres head. Note that 10kPa is approximately 1 metre head. Note that water supplies for fire hydrant and fire sprinklers are required t be sufficient for simultaneous operation.

The traditional process for determining the available flows and pressure in the town main is to attach one or more McCrometers (flow measuring equipment) to underground "spring" hydrants in the street and measuring the flows and pressures available. For the layman, sprig hydrants in the street are identified by reflective blue markers in the middle of the street.

FSCS has produced a paper "**Fire Hydrant Flow Testing**" which explains this and details the problems with reliance on the results. This paper can be downloaded from the FSCS web site **http://fscs-techtalk.com** .

The results from the testing were used to determine whether or not tanks and pumps were required and where the town main appeared to provide copious flows, designers would assume that a single (allowable) connection could supply multiple system requirements simultaneously

This process of determining available flows and pressures should no longer be used because it only provides the availability at a single point in time and is unreliable. This process has now been replaced by the local water supply provider using a network analysis to determine the water flows and pressures that they can supply. It is important to understand this process because significant limitations are imposed ion the connection.

Each of the State water supply providers such as Unitywater has to implement the various planning schemes outlined in the Department of Natural Resources & Mines document entitled "***Planning Guidelines for Water Supply and Sewerage, April 2010***" document and the water supply provider need only supply water as per the policy and table of flows and pressures reproduced below.

Flow Provision is the flow that the network analysis calculates as being available under the policy directives and will vary dependent on the type of development, and the capability of the community to resource fire protection.

Maximum Residual Pressure is the pressure that the network analysis calculates as being available.

Minimum Residual Pressure is 12metre head or 120kPa, being the residual pressure which will maintain a positive pressure on the suction side of the fire authority appliance when operating at the minimum fire flow.

Note that the **Flow Provision** and **Minimum Residual** pressure are guaranteed. However the ***Maximum Residual Pressure*** is not guaranteed as discussed later.

Item	Description
Flow Provision – General Urban Category (Section 5.7.6)	
Residential building (3 storeys and below)	15 L/s for 2 hour duration
High Density Residential building (greater than 3 storeys)	30 L/s for 4 hour duration
Commercial / Industrial building	30 L/s for 4 hour duration
Risk Hazard building	Refer to 'Risk Assessment' provision below
Flow Provision – Small Community Category (Section 5.7.6)	
Residential buildings (up to 2 storeys)	7.5 L/s for 2 hour duration*
Non-Residential buildings (up to 2 storeys)	15 L/s for 4 hour duration*
Other buildings	Refer 'General Urban' category above
Residual Pressure (Section 5.7.7)	
Minimum Residual Pressure – In the main at the hydrant / dedicated fire service	12 metres head
Maximum Residual Pressure – In the main at the hydrant	65 metres head (> 65m requires QFRS consultation)
Minimum Pressure – Elsewhere in the supply zone during a fire event	6 metres head

The upshot of this policy is that the Architect or Hydraulic Consultant will have to request a "Network Pressure and Flow Data" request from their water supply provider.

The five SEQ water service providers that have worked together to develop the SEQ Code are:

Gold Coast City Council, Logan City Council, Queensland Urban Utilities, Redland Water and Unitywater (Sunshine Coast). The Unitywater website for downloading the Network Pressure and Flow Data request form is http://unitywater.com/forms.aspx

Reproduced below is a letter from Unity Water to FSCS providing information for a recent FSCS project. It is reproduced to highlight the typical flows and pressures available (for the subject site) and the impediments that might result on a project.

Careful examination of this letter indicates that for the subject residential (>3 storey) building, Unitywater's analysis is that they can provide 30litres/second (l/s) of water at a residual pressure of 49m (~490kPa).

However it should be noted that they only guarantee a 12m residual head.

Table 1 in the letter is consistent with the Government policy and for the purposes of this paper it should be noted that multistorey residential or commercial developments are limited to a flow of 30l/s, regardless of inclusions such as car parks. The calculated residual pressure will vary dependant on site location.

Note the suggestion in the letter recommending getting advice from a consultant.

Unitywater
Serving you today,
investing in tomorrow.

RECEIVED 4 MAR 2014

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ABN: 89 791 717 472

[redacted]

Rick Foster
Fire & Security Consulting Services
17 McKenna Court
NOOSAVILLE QLD 4566

3 March 2014

Dear Mr Foster

Network Pressure and Flow Data – Request for information – [redacted]

I refer to your application received by Unitywater on 26 February 2014 in which you request pressure and flow data for the above property

Minimum Standard of Service
In accordance with Queensland Government Guidelines Unitywater designs, constructs, operates and maintains its water supply network to provide the following minimum standard of service a 2/3 of the calculated maximum hour demand on the peak day:

Table 1 –*Minimum Standard of Service*

Type of Use	Flow Available from Unitywater's Water Main for Fire Fighting Purposes (litres/second)	Residual Head in Water Main Servicing the Use (metres)
Residential including multi – storey residential dwellings of less than 3 storey	15	12
Commercial that is ancillary to residential use	15	12
Multi-storey residential greater than 3 storey	30	12
Commercial and or Industrial	30	12

Unitywater does not guarantee that fire fighting flow will be available at all times on the grounds that components of Unitywater's water supply infrastructure may be shut down temporarily for planned maintenance or to repair bursts or damage caused by others.

The current type of use for this property is Multi-storey residential greater than 3 storey. Hence, in accordance with Table 1 above, the Minimum Standard of services that applies is 30 litres/second at 12m residual head.

Current Dynamic Model Data
Unitywater's current dynamic water supply model indicates the following under a demand condition of 2/3 of the estimated maximum hour demand on the peak day in Year 2031.

Table 2 –*Estimated Available Flow and Pressure to 2031*

Assessment Node	**Node Location**	**Water Main Diameter *(mm)***	**Estimated RL at Assessment Node**
N002877	Cnr of No 8	150	20.35
Background Demand *(litres/second)*	**Static Head *(m)***	**Fire Flow Demand *(litres/second)***	**Residual Head *(m)***
2.3	60	30	49

Unitywater reserves the right, at any time, to change the operating pressures within the water supply network, but not below the Minimum Standard of Service stated in Table 1.

Unitywater accepts no liability whatsoever for changes in the operating pressure of this water supply network and the consequent impacts on any fire suppression system within the subject property. It shall be the property owner's responsibility to ensure that any fire suppression system operating on the property complies with the relevant requirement of the Building Code of Australia and that this system is regularly tested for compliance with the relevant standards. Any upgrade of the fire suppression system required due to changes in the operating pressure of the water supply network will be the property owner's responsibility.

Suggested Approach to Design of Fire Suppression System
It is suggested that the owner of the property consult with a qualified and suitably experienced hydraulic designer to consider the risks associated with designing a fire suppression system for the subject property based upon the output from Unitywater's current dynamic water supply model. Unitywater may alter the operating pressure of the network at any time.

It is suggested that this risk should be balanced against the cost of designing and installing a fire suppression system that would provide the desired level of performance when supplied with water from Unitywater's mains at the Minimum Standard of Service stated in Table 1.

It may be beneficial to consider providing space and conduits on the subject property that could be utilised for installation of storage tanks and or pumping equipment and associated electrical equipment in the instance that an upgrade of the fire suppression system was necessary in the future.

Further Information
Should you require clarification of the foregoing please contact Unitywater on 1300 086489 during business hours or by email to Asoka.Kiriella@unitywater.com.

Yours sincerely,

Michael Lukin
Manager Network Planning
Unitywater
[redacted]

4 - SYSTEM REQUIREMENTS

The Architect should make judgment as to the requirement in a building; the following provides advice in interpreting Part E in the BCA covering the following systems.

- **Fire Hydrants.** BCA Part E1.3 advises that buildings with a floor area >500m^2 require hydrants. Note the proviso that this only applies where a fire brigade is available to attend a fire. The QFES website provides clarification of this which is included in the paper entitled "***QFRS Interpretations and Guidelines***" on the FSCS web site. For ease of access, it is reproduced below.

  The Building code of Australia (E1.3) required the installation of a fire hydrant system to serve a building having a total floor area greater than 500m2 and where a fire brigade is available to attend a building fire. QFRS interprets the words "where a fire brigade is available to attend" to refer to a situation where:

  A fire brigade is staffed by:

  - *QFRS permanent fire-fighters, or*
  - *QFRS Auxiliary fire-fighters, or*
  - *A combination of (i) and (ii), or*
  - *Fire-fighters from a private fire service who are trained in structural fire fighting techniques and have a pumping appliance available (example – Hamilton Island), and*

  Whilst the Hydraulic Consultant will carry out the design, it is useful here to introduce the Architect to the design principles of a fire hydrant system so that pump and tank sizes can be determine and therefore space allowed in the building.

  Accordingly the Architect needs to determine the need for a fire hydrant system. Should this be the case it is necessary to refer to AS2419.1 (2005) table 2.1 reproduced below where the flow rates are prescribed. It is known that the 2005 edition is soon to be superseded but the public comment draft indicates no change to Table 2 .1 below.

AS2419.1 2005 TABLE 2.1

NUMBER OF FIRE HYDRANT OUTLETS REQUIRED TO DISCHARGE SIMULTANEOUSLY ACCORDING TO BUILDING CLASSIFICATION AND FLOOR AREA

Building classification (see BCA)	Fire compartment floor area m^2	No. of fire hydrant outlets required to flow simultaneously (Note 1)
2, 3, 5 and 9 (1 or 2 storeys contained)	≤1 000	1
2, 3, 5 and 9 (1 or 2 storeys contained)	>1 000 ≤5 000	2
2,3,5 and 9 (3 or more storeys contained)	≤500	1
2,3,5 and 9 (3 or more storeys contained)	>500 ≤5 000	2
6, 7 and 8 (Note 2)	≤500	1
6, 7 and 8	>500 ≤5 000	2
All classes sprinklered	>5 000 ≤10 000	2
All classes sprinklered	>10 000	3
All classes unsprinklered	>5 000 ≤10 000	3
All classes unsprinklered	>10 000	3 plus one additional fire hydrant for each additional 5 000 m^2 or part thereof

In the majority of cases covered by this paper the hydrants requirements will be 2 hydrants each with a flow of 10l/s. The residual operating pressure for the most remote hydrant is required to be 350kPa.

Hydrant coverage for internal hydrants is required such that all portions of the building floor plate (including open balconies and the like) can be reached with a 10m hose stream from a 30m hose located as discussed below, Note that unless otherwise approved by QFES, hydrants can only serve the floor level at which they are located.

In Class 2, 3 and 5 occupancies the location of internal fire hydrants is required to be in the isolated stairs and the stair landing design should be such that it can accommodate the hydrant without impeding egress, Figure 1 below shows a typical arrangement.

Figure 1 – Hydrant in Fire Isolated Stair

In a Class 7a car park, the location of internal fire hydrants is required to be in the isolated stairs. Where the fire isolated stairs serving a car park discharge into ***open space***, an eternal fire hydrant may be used with the approval of QFES. That has advantages in that the coverage for external fire hydrants is that all areas can be reached with a 10m hose stream from a 60m hose located as discussed below. Designers should note that this arrangement requires the hose to be run down the stairs and the length of hose within the stairs should be allowed for, Figure 2 below shows the length of hose contained within two common types of stair design. Note that an external fire hydrant requires the same level of protection as described later for the Booster and shown in Figure 3 below.

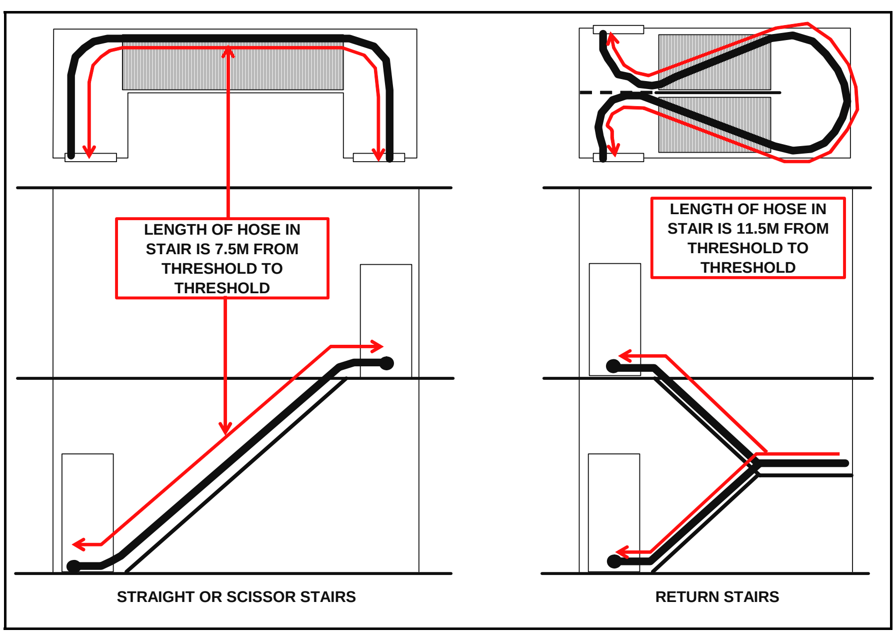

Figure 2 – Hose Length in Stairs

Figure 3 – Protection of External Hydrant

The next stage will be to analyse the required flows and pressures for the hydrant system. , AS2419.1 table 2.1 for a floor or ***fire compartment*** area of **=/>**500m^2 requires 2 operating hydrants (20l/s) but when the floor or ***fire compartment*** area is **>**500m^2 there is only a requirement for one operating hydrant (10l/s).

A Class 7a car park, if >500m^2 and **<**5,000m^2 will require 2 operating hydrants and if **<**500m^2, only one operating hydrant (10l/s).

Where the car park is **>**5,000m^2, it can safely be assumed that it will be sprinkler protected and AS2419.1 table 2.1only requires 2 operating hydrants (20l/s).

For the purposes of this paper and assuming that a residential or office building of more than three stories with a basement car park is the subject project, the water supply provider will have advised that 30l/s is available, this will adequately cover the 2 operating hydrants (20l/s).

The next stage will be to determine the available pressure at the most hydraulically remote hydrant, for a multi storey building this will be at the top floor or, if accommodating plant rooms and the like, the roof level. Note that when all the ***required*** hydrants (either 2 or 1) are operating simultaneously, a residual pressure of 350kPa is required.

For a multistorey building the water pressure will reduce with the combined losses due to static head and friction. Therefore for a seven storey building with an effective height of ~24m, the combined losses for a flow of 20l/s will be ~450kPa and for a three storey building ~250kPa. See page 19 for a guide to the calculation of pump power.

When you get the Network Pressure and Flow Data it will provide sufficient information to make a judgment as to whether a booster pump is required.

Assuming that the water supply provider has advised that a Maximum Residual Pressure of 500kPa is available (which probably common in urban areas), it is apparent that even for a three storey building, the pressure loss of 250kPa will result in a residual pressure of 200kPa, less than the 350kPa required.

Accordingly and unless otherwise advised by the Hydraulic Consultant, a hydrant booster pump and pump room will be required. Diesel booster pumps are preferred unless an on site electrical generator is available to power an electric pump.

Even if the water supply provider can provide higher pressures, it must be cautioned that the estimate provided by the water supply provider is ***not guaranteed***, ***only 12m or ~120kPa is guaranteed***. Therefore the Architect should, in conjunction with the Client and the Hydraulic Consultant, decide whether to omit the provision of a booster pump. This is a risky strategy because water supply providers are increasingly reducing town main pressures to reduce leakage rates.

FSCS advises that as a minimum, the provision of a pump room in the building is made together with power supplies etc. This will enable, if residual pressures are reduced, the cost efficient retro-fitting of a pump.

For hydrant systems, a 4 hour water supply is required, for a 20litre/second demand; this equates to a total of 288,000 litres or a tank of 288m^3 capacity! Obviously the hydrant system should use the town main as the supply which in urban areas should be adequate for the purpose and generally no tanks are required.

Regardless of whether a pump is installed, a Fire Brigade Booster is required to be provided. AS2419.1 2005 provides the requirements which are summarised below. This should be sufficient for the Architect to allow for space and location.

- Located at street level within 8m of a location for a Fire Appliance.
- If within or affixed to the main building, within site of the main entrance and separated from the building with construction of FRL 90/90/90 extending not less than 2m either side of and 3m above the upper hose connections.
- If remote from the building, within site of the main entrance, adjacent to the principal entrance to the site and not less than 10m from the building.
- If closer than 10m to the building, protected with a masonry wall of FRL 90/90/90 extending not less than 2m either side of and 3m above the upper hose connections.
- Not less than 10m from liquefied petroleum gas (LPG) and other combustible storage.
- Not less than 10m from any high voltage electrical distribution equipment such as transformers etc. "High voltage is defined in AS3000 as "exceeding 1,500v AC or 1,000v DC. Obviously 240v AC and 415v AC supplies are included. See **Note 1** below.

Note 1 - Solar photovoltaic panels generate voltage between 400v and 600v DC. The Australian Standards do not required remotely controlled isolators at the solar panel location and therefore the down feeds through the building to the main switchboard are always live.

Figure 4 below shows the protection required for an external booster. Note at the right there is an external fire hydrant to serve the car park.

Figure 4 – External Booster Protection

Note that it is NOT necessary to have a “red box” to house the booster, stainless steel enclosures with hinged doors or even masonry structures are acceptable as long as they have the necessary signage as per Figures 5 and 6 below.

Figure 5– Stainless Steel Booster Cabinet

Figure 6 –Enclosure with Roller Shutter – referred to in Coolum Beach as “The Taj Mahal”

Should it be determined that a pump is required, a suitable space on the Ground Floor or in the basement car park should be provided.

The “Pump Room” section in this paper addresses the spatial, mechanical and electrical services required for the pump room, it is recommended that the Architect read this section in order to allow for the location, access and spatial requirements.

It should be remembered that the pump room is a working environment and Occupational Safety and Health Regulations apply.

Accordingly FSCS reinforces this by advising that the following location, access and spatial objectives should be achieved.

- Independent access for the Fire Brigade directly from the outside of the building. Should independent access not be feasible, access from a basement car park via the required egress stair may be acceptable subject to an Alternative Solution being formulated. In that case a stair lobby would be required in the basement typically as shown in Figure 7 below from a recent FSCS design accommodating hydrant and sprinkler pumps and sprinkler tanks. The size for a single hydrant booster pump is discussed below. Note that Figure 7 also shows the following features that are required.

- The required FRLs bounding the compartments.
- A maintenance access door from the car park. FSCS has frequently seen pump rooms constructed where the only way to install the fire pumps is to dismantle them, take each part down the stairs and then reassemble. This process is very costly because after reassembly the factory test certificate may be void and an on site test carried out. Later, if and when pump replacement is contemplated, the reverse has to be carried out.
- Preferred location near the car park supply and exhaust ventilation ducts. Note that **no** dampers shall be installed in these ducts.
- Ventilation ducts (supply and exhaust) for the pump room. Note, **no** dampers shall be installed in these ducts.
- The preferred location of the Fire Brigade Booster assembly is shown above the area.
- Space for the fire hydrant booster pump. Typical fire pump sets are approximately 1.5m long x 0.75m wide. With the required space around it as advised by QFES below, a typical single hydrant booster pump room should have minimum of dimensions of ~3.5m x ~3m x 2.5m in height. This will provide for the required clearance around the pump and the 2.1m headroom.
- QFES have published guidelines for fire service pump enclosures as follows:-
  Fire pump enclosures require a minimum of:
  - *2.1 metres head clearance.*
  - *1 metre wide, clear path of travel to the fire pump controller.*
  - *1 metre wide, clear path of travel to the manual shut-down for diesel drivers.*
  - *1 metre wide, clear path of travel to all other required control valves.*

  These minimum requirements are supported by:
  - *Building Code of Australia 2009 (Part E1).*
  - *Australian Standard 2941-2008 (Section 11, Clause 11.3).*
  - *Australian Standard 2419.1-2005 (Clause 6.4; Sub-Clause 6.4.1).*

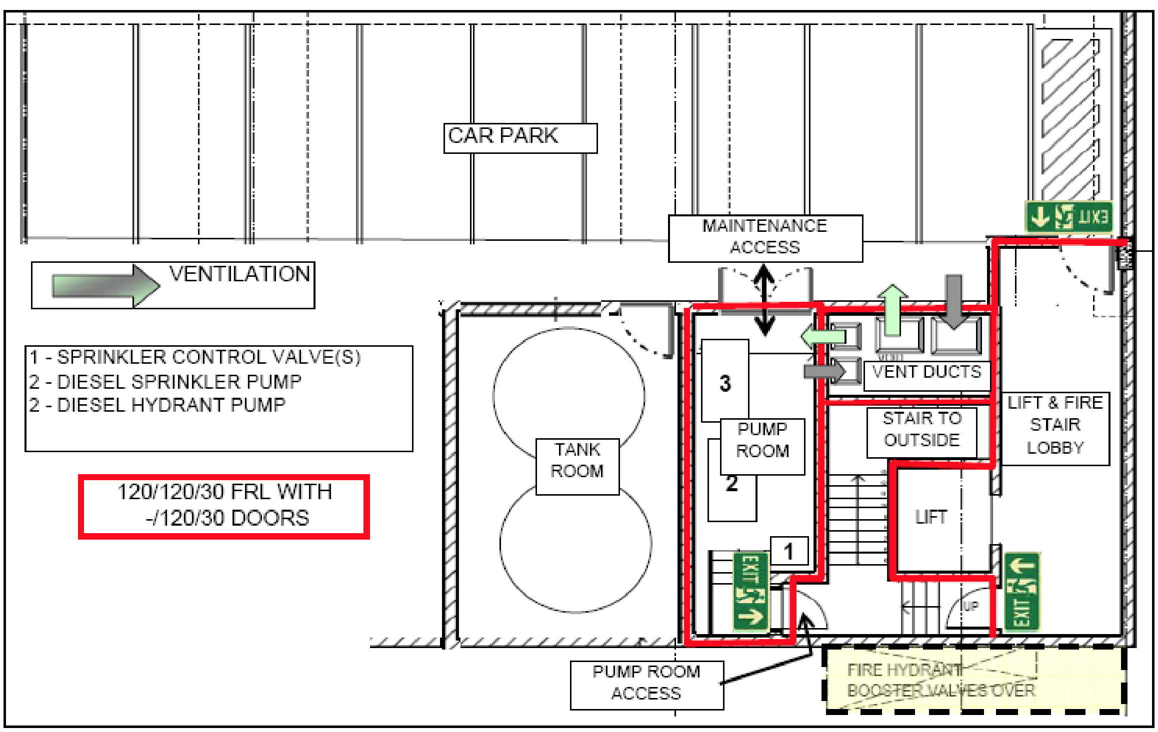

Figure 7 – Fire Pump Room & Tanks

- **For Sprinklers**, the current BCA adopts the 1999 edition of AS2118.1. This despite the publication of a revised edition in 2006! The reason behind this is that prior to 2006 the Australian Building Codes Board (ABCB) had decided to develop their own sprinkler standard based on life safety principles and protection of occupants up to the point of successful evacuation, and not on building protection. This failed to gather any impetus mainly because all the State Fire Authorities have disagreed with the principles.

  Following the rejection of the ABCB initiative, the Standard was rewritten in 2008 and accommodated the concerns of the Fire Authorities and incorporated most of the AS2118.1 2006 features. It was published in draft from in 2008 and nothing has been heard of it since!

  Sometimes, especially in commercial and industrial occupancies the 2006 edition provides for more advanced designs and can be used as an Alternative Solution

  BCA Part E1.5, lists the building occupancies that are required to have sprinkler protection, these include:-

  - Buildings with an effective height >25m; and
  - Buildings with high hazard storage, the BCA provides a comprehensive but for the purposes of this paper it is not considered that Class 2 3 or 5 occupancies will be included.
  - Basement (enclosed) car parks accommodating 40 or more vehicles. Note the term "vehicles" in the BCA. The QFES may include registered motorcycles in the number of vehicles. A basement car park with 39 "car" spaces" and 1 motorcycle space <u>may</u> trigger the requirement for sprinklers!

  Whilst the Hydraulic Consultant will carry out the design, it is useful here to introduce the Architect to the design principles of a sprinkler system so that pump and tank sizes can be determines and therefore space allowed in the building.

  AS2118.1 categorises the various areas in a building according to the hazard classification. For the purposes of this paper where Class 2, 3, 5 and 7a occupants exist, calculations can be made as to the quantity of water required.

  The Class 2 and 3 residential and the Class 5 office occupancies are a "Light Hazard" "LH" category with a design density of water discharge equal to 6 sprinkler heads each discharging 48litres per minute. This results, after applying a typical "hydraulic gain" **§** of ~15% a total flow of ~331litres per minute. For the 60 minute supply requirement, this equates to ~20,000 litres.

  The Class 7a car park is an Ordinary Hazard Group 2" "OH2" category with a design density of 5mm/'min (5 litres/minute/m^2) over a design area of 144m^2. This results in, after applying a typical "hydraulic gain" **§** of ~15%, a total flow of ~828 litres per minute or 13.8l/s. For the 60 minute supply requirement, this equates to ~49,680 litres.

  § The FSCS paper " **Hydraulic Gain in Sprinkler System Design (V2)" on the FSCS** web site **http://fscs-techtalk.com** discusses this issue.

  Note that the Australian Standards require the sprinklers and hydrants to operate simultaneously which is why a cost effective design is to have the fire hydrant system supplied from the town main and the sprinkler system from a tank supply.

  For the project being considered in this paper, reviewing the water supply available and the hydrant requirement, it is obvious that with a 20l/s hydrant demand and a 13.8l/s sprinkler demand, the total water demand of 33.8l/s will be greater than the 30l/s available. In this case we must provide a tank supply.

The BCA advises that the Grade of water supply to a ***required*** sprinkler system must not be less than-

- For a building greater than 25 m in ***effective height***, Grade 1, except that a secondary water supply storage capacity of 25,000 litres may be used if:-
- the storage tank is located at the topmost *storey* of the building; and
  - the building occupancy is classified as no more hazardous than Ordinary Hazard Group 2 (OH2) under AS 2118.1; and
  - an operational *fire brigade* service is available to attend a building fire
- For a building not greater than 25 m in *effective height*, at least Grade 3.

The BCA requires that any building **>**25m in ***effective height*** is required to have a "Grade 1"water supply which comprises two pumps, one being diesel and the other electric drawing from two tanks , one being the full capacity and the other being a lesser capacity allowing for make up flow from the town main. Other arrangements are permissible but this is the most common.

For buildings **<**25m in ***effective height*** a grade 3 water supply may be used which comprises one pump, either diesel or electric drawing from one "limited capacity" which means that make up flow from the town main can be utilised. . Other arrangements are permissible but this is the most common.

As calculated previously, a typical LH sprinkler system water supply would be in the order of 20,000 litres or 20m^3, however a 25,000 litre or 25m^3 capacity should be used and FSCS advises that in its opinion, town make up should not be considered.

As calculated previously, a typical OH2 sprinkler system water supply would be in the order of 50,000 litres or 50m^3.Where town main make up is available as discussed in the project being considered, the availability is 10l/s, being the difference between the available 30l/s and the required hydrant demand of 20l/s. Over the 60 minute operating period of the sprinkler system, a town main infill of 36,000 litres is available resulting in a tank capacity 14,000 litres or 14m^3. This is a significant reduction however AS2118.1section 10.2.2.3 stipulates a minimum tank capacity of 50,000 litres or 50m^3.

These capacities are the effective capacities which do not take into account the air gap above the infill pipe and the distance between the bottom of the tank for the vortex plate. The tank capacity should be increased to allow for these features and generally FSCS would allow for 300mm being added to the nett tank height Figure 8 below shows this arrangement.

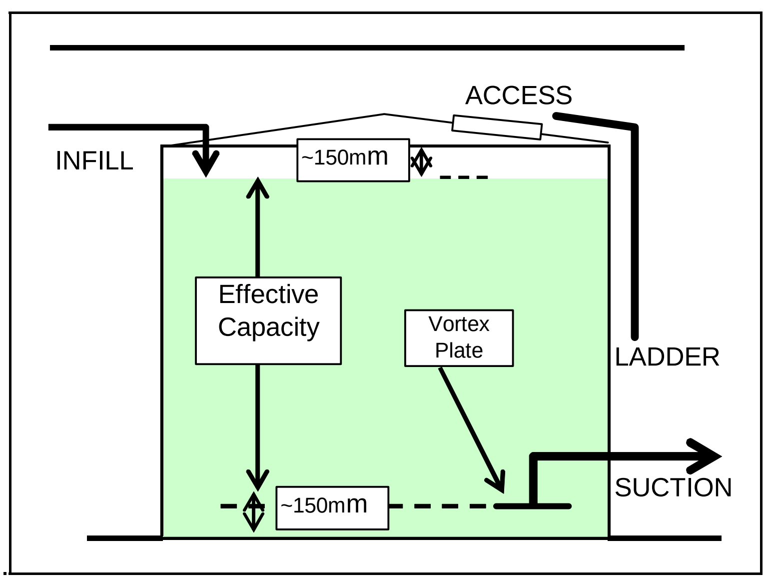

Figure 8 – Tank Details

For the required pumps and tanks, a suitable space on the Ground Floor or in the basement car park should be provided. The sprinkler pump can be incorporated into the same space as the hydrant pump. Figure 7 earlier in this paper shows a combined hydrant and sprinkler pump room with a tank room adjoining.

FSCS is frequently consulted regarding the type of construction used for tanks, many installations use tanks “built in” to the concrete structure but this is not cost effective and leads to significant installation and maintenance problems due, amongst other things, leakage. Figure 12 later in this paper shows a “leaky” pump room and tank.

Suction and fill pipes are difficult to cast into the concrete sides and it is usually impossible to design the tank so that a manhole is provided for cleaning access. FSCS has been consulted midway through a project where the top of the tanks were the Ground Floor slab, in that case we had to cut an opening in the sides and fabricate bolted access hatches – see Figure 9 below.

Figure 9 – Bolted Access Hatch

Consequently FSCS recommends the use of circular steel tanks complying with *AS2304 2011 – Water Storage Tanks for Fire protection Systems,* installed within a separate room off the car park as shown in Figure 7. These tanks are delivered in modular form with the components being able to be transported through normal doorways and subsequently assembled on site. This has been found to be the most cost effective solution because these tanks are common in the fire protection industry.

Designers should be aware that the maintenance requirements for tanks in AS2304 require that steel tanks shall be emptied annually for inspection. Where liners are present, the additional work associated with the annual service and likely replacement of liners will incur significant costs. Accordingly FSCS recommends that tanks without liners should be used, usually epoxy lined, as currently used in the industry.

Because of the requirement for all tanks to be drained and cleaned annually, the sprinkler system supply shall incorporate a connection, via a “RPZ” backflow preventer to the town main supply for use during tank maintenance and cleaning. This can be costly and complicated and FSCS recommends that sprinkler system water supplies shall be in two tanks, each of 50% capacity allowing for uninterrupted protection. This is in concert with AS2419.1, the hydrant Code which has a similar requirement. Consequently Figure 7 shows two tanks.

Based on the above, a sprinkler system with a supply requirement of 50,000 litres can be in two 5.4m diameter x 2.5m high tanks. These dimensions fit neatly into a car park area with a slab to slab height of 3.5m and still leave sufficient height for an access hatch at the top of the tank as shown in Figure 8.

It is important to understand that the fire pumps and water tanks are on the same level. In one building that FSCS was asked to investigate, the tank had been constructed beneath the fire pump room, ***in this case the pumps would not function***.

Although a single electric pump is permitted, FSCS strongly recommends the use of a diesel pump. As discussed later, where a single electric pump is used the power supply needs to be addressed. Details of these requirements are provided in the "Pump Room – Electrical" section of this paper.

The costs of these additional features likely to exceed the difference between a diesel and electric driven pump.

Later, this paper lists the mechanical and electrical services required for the pump room and as before, it should be remembered that the pump room is a working environment and Occupational Safety and Health Regulations apply.

For the Architect however, the following should be considered:-

- Sprinkler Control Valve. This may be located in the pump room provided an additional 1.0m x 1.0m of space is provided for access.
- As discussed for the hydrant pump room, independent access for the Fire Brigade directly from the outside of the building. Should independent access not be feasible, access from a basement car park via the required egress stair may be acceptable subject to an Alternative Solution being formulated. In that case a stair lobby would be required in the basement typically as shown in Figure 7.
- Pump room dimensions for one sprinkler and one hydrant pump would be in the order of ~3.5m x ~3m x 2.5m in height. This will provide for the required clearance around the pump and the 2.1m headroom.
- Separate location for sprinkler tank to accommodate one 50,000 litre tank. FSCS recommends that for ease of installation and two 5.4m diameter tanks as previously discussed.
- Diesel exhaust lagged to 2.1m height and routed to outside the building with the outlet not closer than 6. to a building ventilation inlet. This may require the exhaust pipe being run in the fire isolated shaft housing the car park exhaust ducting.
- ➢ Pump details and performance as described in the "Pump Room" section.
- ➢ Water supply connections and drainage as per "Pump Room" section.
- ➢ Mechanical ventilation as described later in the "Pump Room" section.
- Electrical power and lighting services as described later in the "Pump Room" section

When a sprinkler system is installed, the Fire Brigade Booster shall also incorporate a sprinkler boosting connection and tank suction.

- **For Fire Hose Reels**. BCA Part E1.4 advises that for buildings with internal fire hydrants, hose reels are required. Note that the 2014 edition of the BCA, Part E1.4 dispenses with the requirements for hose reels in the residential portions of the building. However they are still required for the other Classifications in the building such as offices, shops, car parks and the like.

  To offset this requirement, an ABE 2,5kg Dry Powder Portable Fire Extinguisher is required in each residential lobby no further than 10m from any residential sole occupancy unit entrance. This dispensation will remove the need for hose reel cupboards and likely the need for a hose reel pump, saving costs and contributing space back to the building.

- **Pump Room.** – AS2419.1 (Fire hydrant installations) and AS2941 (Fixed fire protection pumpset systems) provide details on the requirements for pump rooms. AS2419.1 also has a mandatory requirement for a weatherproof pump room.

  FSCS is of the opinion that these should be seen as guidelines only and that the appropriate designers and Consultants should apply the necessary Codes and Standards in terms of the environmental conditions considering that, as previously discussed, the pump room is a working environment and Occupational Safety and Health Regulations apply.

  In addition to the AS2419.1 and AS2941 requirements referenced above, QFES have published additional guidelines for fire service pump enclosures and tanks at:-

  https://www.fire.qld.gov.au/buildingsafety/guidelines.asp

This paper has incorporated such details as necessary in this paper but Consultants are encouraged to view the QFSE site.

FSCS provides the following advice to designers and consultants in respect to pump room design. It should be noted that this is advice only but it is based on the BCA, Australian Standards and relevant Occupational Health and Safety Codes.

General Design Considerations

- Fire pumps cannot be stopped automatically. Only the stop functions on the starters, or in the case of a diesel pump, the governor shut off.
- Each pumpset shall be fitted with a circulation relief valve to prevent overheating from churning at low or no flow.
- AS1851.1, the Australian Standard for maintenance, requires weekly inspections but as allowed under Clause 3.2.1 of that Standard, permits monthly inspection subject to the fitment of dual battery systems, low battery voltage monitoring and low fuel level monitoring. FSCS recommends that this feature be adopted where a monitored FIP is present in the Building. Otherwise private monitoring can be arranged.
- Restrictions in the pump suction piping such as butterfly valves are *not permitted*. This is consistent with NFPA20 and FM Global requirements.
- The QFES requirement for painting pipework to AS1345 as noted in AS2941 has presented approval problems in the past. AS1345 comprises three elements for the identification of pipes, conduits and ducts and include the base identification colour, pipe marker and supplementary colours.

  AS 1345 determines the location and the form of the three elements. This includes the general requirements and form of marking.

  The base identification colour is a single colour that is intended to provide immediate information on the contents of the pipe. When applying the base identification colour the pipe can be completely painted with the identifying colour, or regularly banded with the identifying colour or identified with proprietary markers with the following characteristics:

  - background colour is the same as the base identification colour;
  - lettering in either white or black;
  - lettering that is large enough to be read by normal eyesight;
  - contrasting border around the label in white or yellow;
  - chevron within the border indicating the direction of flow within the pipe.

  Accordingly FSCS considers that pipe identification can be by any of the above and pipe does not have to be completely painted.

Non Slip Flooring

Pump rooms frequently have water leaks present on the floor which present a significant hazard to occupants. This is especially serious when hot and / or moving machinery parts are present. FSCS has seen pump room floors with polished concrete finishes; they look good but can be deadly.

Accordingly FSCS recommends that the floor surface be treated with a non slip application.

Such treatments can be a simple as a coarse brush finish to the concrete after pouring to durable two pack epoxy paints containing a coarse granular substance.

Coatings such as from Roxset (www.roxset.com.au) are typically used in the food processing industry.

Ventilation

Being a workplace where maintenance personnel as well as attending fire fighters are likely to be in attendance, ventilation is required for the following:-

- Cooling the diesel engines.
- For combustion air.
- Environmental air.

The calculations below are for a pump room located within the building and provided with mechanical ventilation. Figure 10 below shows a typical system and with a supply air (outside air) temperature of 30^{o}C, the target room temperature is 40oC.

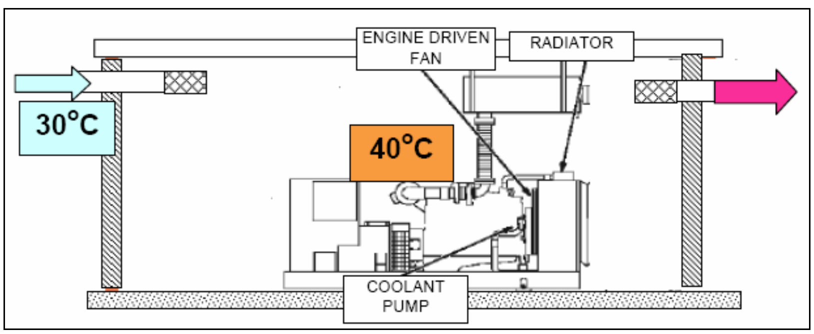

Figure 10 – Pump Room Temperature

The Cummins Engineering Standard 027 for Engine Room ventilation calculations provides detailed methodology for precise calculations. This is available for download at

http://cumminsfirepower.com/documents/ES027ventilation.pdf

Where pump rooms are located outside the building in a separate "shed", natural ventilation such as from the engine radiator fan is usually sufficient. Figure 11 below shows a typical installation.

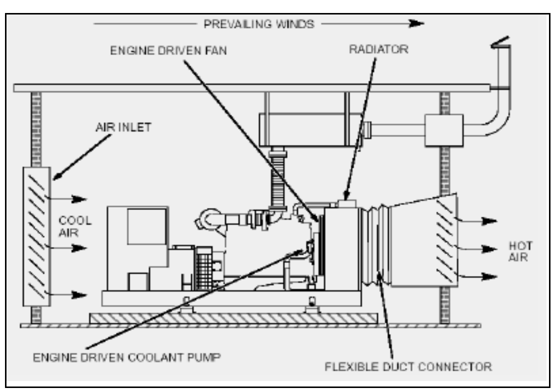

Figure 11 – Natural Ventilation

Typical ventilation calculations are shown below:-

- Cooling the diesel engines. The heat generated from typical fire pump engines is discussed below. Generally for pump rooms in ambient conditions an air flow of ~30 litres/second/kW is required. Therefore for a typical 30kW engine, a cooling air flow into the pump room is 900/s.
- For combustion air. A typical diesel engine requires approximately 1.5litres/second /kW. Therefore, for a typical 30kW engine, combustion air flow into the pump room is 45/s.
- Environmental air, this is to be a minimum 6 air changes per hour which for a pump room with dimensions of 3.5m x 3m x 3.5m, is 61.25/s.

The total ventilation requirements therefore for a single diesel engine in a pump room will be 1,006 l/s with an equivalent exhaust capacity. This can be rounded off to 1,000litres or $1m^3$ per second.

Because of the consumption of the combustion air supply, the pump room will be at slightly negative pressure which will ensure that contaminated air does not leak out of the room.

Where there are two or more engines, the calculations should include for cooling and combustion air, e.g. sprinkler and hydrant pumps operating simultaneously as required by the Standards.

The operation of the ventilation system may be arranged by a relay trip on the pump starters so that both exhaust and supply fans start when the pumps start. Environmental air however, should be operating at all times when personnel are present. This can be interlocked with the lighting.

This variable demand can be met with fan motors having variable speed drives (VSD).

Ideally, the pump room should be provided with ventilation continuously to address humidity issues, one elegant and cost effective way is to install a split system air conditioner, have the condenser unit in the car park and run it on :dehumidify" mode.

Figure 12 below shows a pump room with obvious leakage problem which leads to high humidity and consequent corrosion, Corrosion on the copper pips at top left is clearly seen.

Figure 12 – Pump Room Leakage

Lighting

Being a workplace where maintenance personnel as well as attending fire fighters are likely to be in attendance, lighting in accordance with AS/NZS1680.2.2 – *Interior and workplace lighting* should be provided

The objective and purpose of a lighting system should be considered at the design and installation phases. This is especially significant for workplaces where construction work is performed as the lighting system must be able to accommodate changes in work activities and the progression of construction.

The lighting system should ensure the safety of people to the extent that the lighting makes hazards visible. The facilitation of visible tasks and the creation of an appropriately illuminated environment must also be considered.

The lighting system should, therefore, be designed and installed, so as to reveal the task and provide a safe and comfortable visual environment.

The following workplace issues must be considered for compliance with the *Workplace Health and Safety Act 1995* and the *Workplace Health and Safety Regulation 2008.*

- Task lighting
- Access and stair lighting
- Emergency lighting.

Lighting of at least 240lux is required and where available, the lighting shall be supplied from the Essential Services section of the main switchboard. If no such equipment is available, the lighting shall be "maintained" emergency lighting accordance with AS2293.1. Such lighting is energised at all times when normal or emergency lighting is required;

Pump Power

For those that are interested in calculating the size of a fire pump driver, the following formula may be of interest.

$P_{\mathbf{kW}} = Q_{\mathbf{l/s}} \times H_{\mathbf{kPa}} / 650$

For a pump to provide a flow of 20l/s at a residual pressure of 350 kPa at the top of a 7 storey building where the static and friction losses are 450kPa the following are the inputs:-

$Q_{\mathbf{l/s}}$ = 20l/s, $H_{\mathbf{kPa}}$ = 350 + 450 = 800kPa. Therefore $P_{\mathbf{kW}}$ = 20 x 800 / 650 = **24.6kW**

Electrical

For general use, the pump room should be provided with electrical services as follows:-

- Normal and emergency lighting as described above; and
- A 240v 50Hz 15A power supply to a dedicated board to cater for the jacking pump, pump starters and a 240v 50Hz 15A double weatherproof socket.

As discussed previously in this paper, if it is desired to use a single electric pump for a sprinkler system in a building >25m ***effective height***, the following should be noted:-

- From the "Essential Services" section of the main switchboard; and
- Fire rated supply cables; and
- Building power supply, switchboard and cable sizes suitable for a DOL (Direct on Line) starter which draw between 6 and 7 times the full load current of the pump. As an example, a 30kW 4 pole electric motor running at 1,500 rpm draws a full load current (FLC) of ~54A. the DOL current, although only momentary, is ~350A. A high rupture capacity (HRS) is at least going to be required.

Where two pumps are required such as in a sprinkler system in a building >25m ***effective height***, the electric pump need not have fire rated cabling nor be supplied from the Essential Services power supply. The requirement for cable and power supplies being suitable for DOL starting still remains.

This concession is because the diesel pump can be considered as a "stand-by" in case there is a failure in the electric pump or its power supply.

Hydraulic / Water Supply

Note the use of 4 pole electric motors as described above, where two pumps are required such as in a sprinkler system in a building >25m effective height, the diesel pump will be selected to run at a similar speed. This ensures that identical pumps can be used making calculations much easier.

As discussed previously in this paper, if it is desired to use an electric pump for the sprinkler system, a connection from the town main connection of suitable size for the sprinkler demand should be routed to the pump adjacent to the sprinkler control valve(s).

The pump room should be provided with a large capacity drain suitable for accommodating the discharge from the 2" (50mm) waste valve on the sprinkler alarm valve. It is estimated that the capacity should be ~1.0l/s.

A 150mm test drain is required to be provided at the hydraulically most disadvantaged (remote / highest) hydrant. This is usually in the fire isolated stair.

----------- End of Document---------

I trust that this paper provides useful information for Architects, Design Consultants and Builders in the design and construction of buildings.

QFES Building Approval Officers and Building Certifiers may also fine the information contained herein useful.

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Fire Safety Engineer

RPEQ Mechanical – 7753: Accredited by Board of Professional Engineers as a Fire Safety Engineer

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