ISA Delhi Section

Setting the Standard for Automation™

PETROLEUM AND POWER AUTOMATION MEET 2016

8th & 9th April 2016
(FRIDAY & SATURDAY)

Venue: EROS Hotel, Nehru Place, New Delhi

Standards

Certification

Education & Training

Publishing

Conferences & Exhibits

Message

On one hand the Automation Technology Trends on the global scale are dynamically advancing and on the other there is a need for better synergy required for Process Industry domain including Petroleum and Power segments. In the country where technology and resource sustainability is being sought by the industry and "Make in India" is an area of concern for the Government with regards to sustainability in the future. In such a case it is the Automation Technology that may help reducing this gap as well as become a major factor in meeting the sustainability needs of the petroleum and power sector in India.

It gives me immense pleasure to announce that ISA Delhi Section is once again organizing the Petroleum & Power Automation Meet – PPAM 2016 in Delhi from 8th to 9th April 2016. The role of Automation Technology, specifically Instrumentation & Control is very crucial in this Industry domain to generate efficiency and sustainability in the process industry as well as the infrastructure and utilities. The role of Automation is quite similar not only to create efficiency in oil & gas production technology and to produce and transmit more safe and reliable energy but also it is at the same time very significant in terms of providing economic advantages.

This gathering of automation professionals under the umbrella of ISA Delhi Section, I am sure, would provide the ever needed platform of information exchange among the decision makers in the domain of Petroleum and Power segment. I wish all the participants, sponsors and technical paper presenters a very best of the success for this Mega Event to create dynamic strides in this journey towards switching to the future.

With Best Regards

RGupta

RAJIV GUPTA
President
ISA Delhi Section

Message

Knowledge sharing and continuous engagement of technology leaders is the key to success for any domain including Process Automation. Like in the past two years ISA Delhi section has now been able to successively organize Petroleum and Power Automation Technology show PPAM this year also. I am pleased to reiterate my positive views on the need for such a forum where experts and peers of the industry are able to discuss over common issues.

A platform like PPAM 2016 is an attempt to thrust the oil & gas as well as power industry to the forefront of technology and performance leadership. With the event being attended by the pioneers of Automation industry from India and abroad to identify a future course of petroleum and power industry in India, I feel that it will be able to add value for all stakeholders including the end users, suppliers and engineering companies.

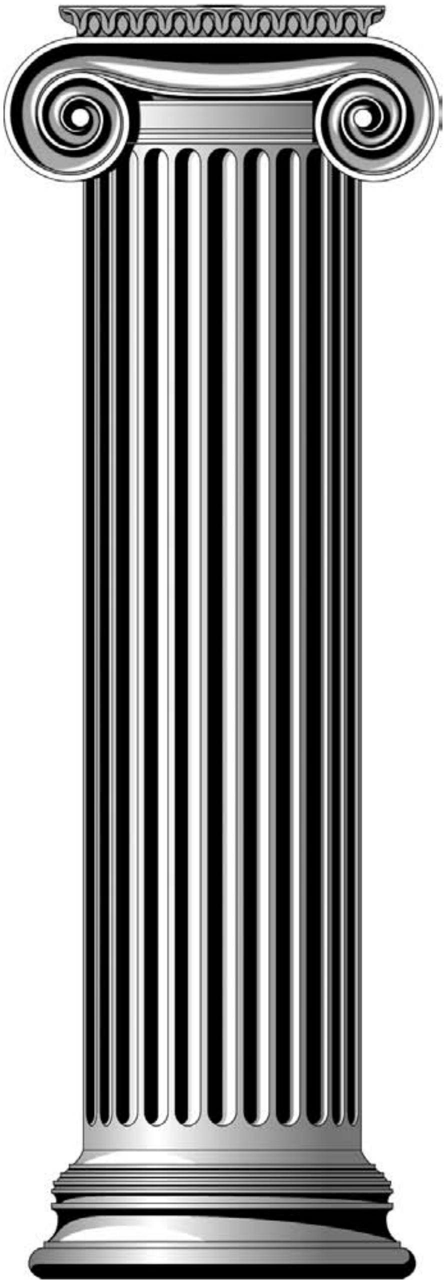
Also considering that the current technology trends of Internet explosion and economic trend of Make in India will be providing a right interface between the automation fraternity as well as the policy makers and regulators in this sector.

I look forward to an enriching two day session where all the participants are able to add value in the field of Automation.

With Best Regards

PRASENJIT PAL
Chief Convenor
PPA Meet 2016

ISA Delhi Section



The International Society of Automation (ISA)

Founded in 1945, the International Society of Automation (ISA) is a leading, global, nonprofit organization that is setting the standard for automation by helping over 30,000 worldwide members and other professionals to meet, interact and share their knowledge. Based in Research Triangle Park, North Carolina, ISA is organised into 14 districts and hundreds of sections across the world. The South East Asia region is designated as District-14 and within this district, the Delhi Section is an active organization drawing members from the entire spectrum of automation industry across Power, Oil & Gas, Metallurgy, Chemicals & Fertilizers including the Engineering fraternity from Consultants, EPC Contractors, Automation Component Suppliers & Equipment Manufacturers, System Integrators and many other industries.

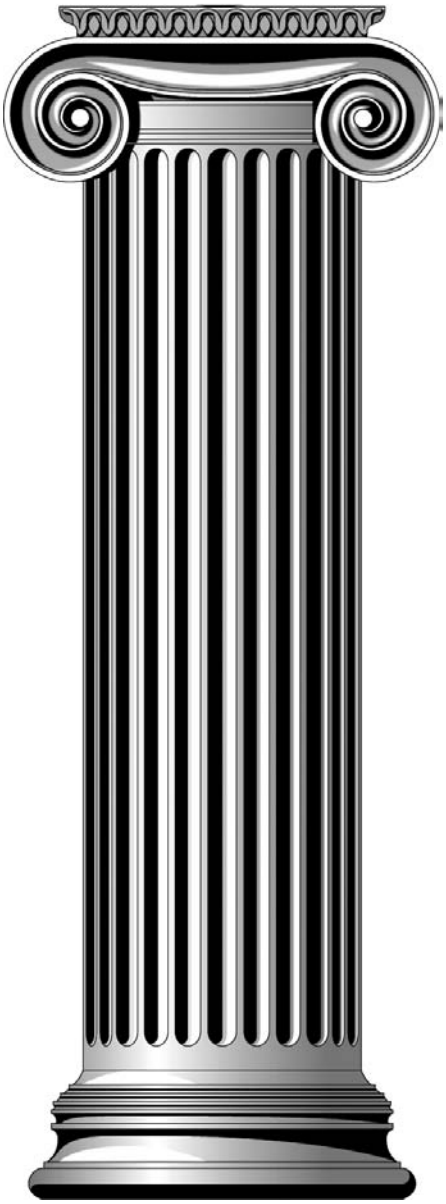
ISA has been involved in promoting emerging technologies across the globe by a variety of ways such as:

- Developing and updating standards for existing & evolving technologies in automation related fields ;
- Publication of Text-books, hand-books, journals, proceedings etc. on a wide array of automation related subjects from primary field sensors to integrated automation and management systems for various kinds of plants & processes;
- Facilitating Interface & interaction with other agencies like IEC, IEEE, EPRI, ASME and others to develop and maintain automation related standards with regular updating, keeping pace with the march of technology in various fields;
- Organising Training, Seminars/Workshops, Webinars and Exhibitions
- Carrying out certification programs for technicians, engineers and senior professionals.
- Recognizing the talented and the dedicated professionals in the field of Automation through various honours and awards
- Enabling Interaction with Student members, formation of student section and annual scholarships, competitions etc. are many interesting student programs of the ISA.

The ISA Delhi Section - ISA(D)

ISA Delhi Section had been formed almost a decade back and has progressed well since then with a membership of more than 350 and growing. ISA Delhi Section had taken many initiatives in the past including organizing two exhibitions ISA (D) EXPO' 05 & '07, a large number of seminars and workshops on emerging technologies. Regular Monthly technical exchanges on diverse topics are organised for the benefit of all members of ISA(D), thereby increasing the knowledgebase & technical capabilities of members.

ISA Delhi Section



ISA Delhi Section has taken quite a few initiatives in the recent past to better address the need for knowledge sharing among industry specific groups of Automation Engineers. Notably, within the overall ambit of ISA(D), two industry specific interest groups have already been created, one for the Power Industry namely Power Automation Technology group(or POWAT) and one for the Oil & Gas Industry called Petroleum & Natural Gas Industries Automation Domain(PNID). ISA (D) is also encouraging the farmation of a systems integrators forum, so as to share the vast scattered knowledge base resources of systems intergrators community.

ISA Standards

Practical Solutions from Industry Experts

ISA Standards help automation professionals streamline processes and improve industry safety, efficiency, and profitability. Over 150 standards reflect the expertise from over 4,000 industry experts around the world. Since 1949, ISA has been recognized as the expert source for automation and control systems consensus industry standards.

Key Features, Advantages, and Benefits of Standards

Realize a direct return on investment by

- Lowering installation and start-up costs
- Reducing need to maintain large inventories
- Enabling interchangeability of components
- Improving design with less "custom" effort
- Increasing safety

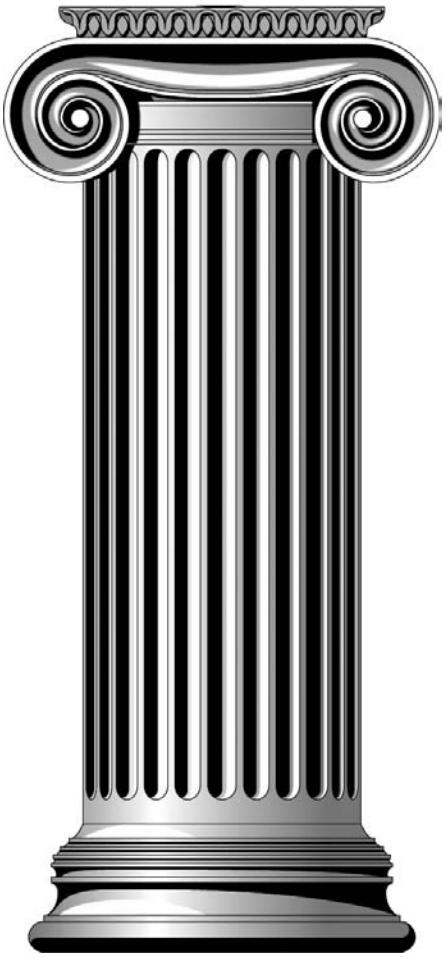
Use of standards in industry

- Improves communication
- Provides practical application of expert knowledge
- Represents years of experience and avoids necessity of starting each project from ground up

Standards help you achieve operational excellence by

- Improving performance
- Lowering maintenance costs
- Reducing downtime
- Enhancing operability
- Saving money

ISA Delhi Section



ISA's Role in Developing Standards

More than 4,000 individuals cooperating with more than 140 committees, subcommittees, working groups and task forces are involved in ISA standards. They're developing standards in areas as diverse as ensuring the safety of electrical equipment used in hazardous locations to cost-savings for interfaces between industrial process control computers and subsystems.

How a Standard Saves Money

ISA's batch control standard illustrates how using a standard cuts costs. Food, pharmaceutical and specialty chemical companies build factories with increasingly sophisticated computer-driven automation. The batch standard ISA developed-ANSI/ISA-88.00.01 - shaves as much as 30 percent off the cost of designing the system and software used in these plants. ANSI/ISA-88.00.01 sets out a blueprint that engineers can use to make portions of the code interchangeable, which is less expensive than designing each piece from the ground up.

The savings extend beyond the facility's design, though. By using the batch standard, companies save as much as 10 to 15 percent off the typical cost of meeting Food and Drug Administration criteria for the reliability of automation equipment.

How a Standard Saves Lives

Other ISA standards focus on safety. ISA has developed standards for the performance requirements of toxic gas detectors, standards to keep electrical equipment from igniting flammable material and standards to ensure safety at nuclear power plants.

And some ISA standards can help an entire industry combine cost savings and safety. The most popular ISA standard is ANSI/ISA-5.1, Instrumentation Symbols and Identification. Developed in 1949 and most recently revised in 2009, these symbols are used in blueprints for everything from power plants to factories. If every contractor on a project knows the standard symbols, there are fewer communication problems that could lead to costly delays or safety problems.

Using Standards to Help Your Business Expand Globally

Your company has a product that's taken the United States by storm; now you want to expand globally. But there is a hitch or, as the engineers might tell you, a "technical barrier to trade.'' Your company's product, or the process by which it's made, doesn't meet international standards. Many ISA standards are also international standards, and our committees strive to stay current with evolving global standards. ISA administers three committees for the International Electro technical Commission (IEC), which is one of the two most widely recognized international standards groups, along with International Organization for Standardization (ISO).

ISA Delhi Section

How Your Company Can Take Advantage of ISA's Standards

- Buy ISA standards and train your employees to follow it.
- Help set a standard. ISA's committees are eager for help. Both voting and non-voting memberships are available. Voting members must have their employers' approval, in part because attending at least one meeting a year is expected. But we're cutting down on the time demands of committee membership by encouraging members to do a great deal of their work via e-mail. Non-voting members supply input but are not required to attend meetings. Apply online to volunteer.

Students

Students can come to automation from a variety of backgrounds and academic programs. It is sometimes difficult for you to find programs that concentrate on automation as a career or specialty. This potential variety can create challenges for students like you that are not seen in many areas of studies.

The essence of automation is that it is a multidisciplinary art, not a single discipline. You are required to know a lot about many things to function as an automation professional. Automation studies are rarely centred in one department. Automation students and faculty on a campus could come from any number of engineering areas. That means that published findings could appear in a number of journals and presented at a myriad of scientific conventions. This diversification makes it extremely difficult for students to stay current on the newest findings. It also means that you need to have a very open outlook on what will make you a good automation professional.

The ISA web site helps students more easily stay current on research without attending numerous expensive conventions or wading through non-automation related literature for the useful gems. Also, students can find the conferences they should attend to both gain information and networking possibilities, which can lead to job possibilities.

The ISA web site contains the Automation Body of Knowledge, from the very basics of sensors and controls to the most detailed industrial networking, enterprise integration, cyber security and safety information. When you have digested that Body of Knowledge, you will be ready to be a Certified Automation Professional, and you can find the tutorials and test materials here to help you.

The ISA Mentor Program for Young Professionals and Students

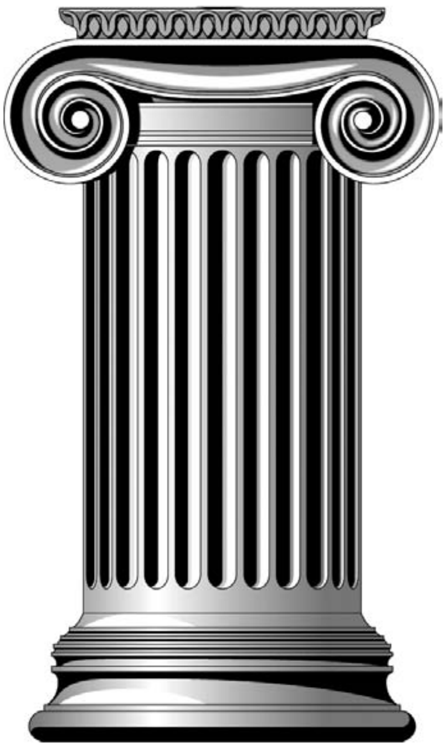
ISA's Mentor Program enables young professional ISA Members and Student Members to access the wisdom and expertise of seasoned ISA Members, while it offers veteran ISA professionals the chance to share their wisdom and make a difference in someone's career. A mentor can give a young professional guidance in his or her career or help a student determine if automation and control is the right path to follow.

ISA's Mentor Program is an online program, so there are no meetings to attend and there is no travel. ISA Members from all over the world can participate, and the relationship can develop and progress at the convenience of the mentor and protégé.

ISA Members are encouraged to register and participate in the program as mentors. Find out more about becoming a mentor.

ISA's younger Members and Student Members are urged to use this valuable Member benefit. Find out more about getting an ISA Mentor and how to select a mentor.

ISA Delhi Section



2015-2016 ISA Section Leaders Report Form

Name of Section: ISA DELHI SECTION **District #:** 14

Person Completing Form: Rajiv Gupta **Position:** President

Effective Date Leaders Take Office: 12/04/2015

Positions were confirmed by: Outgoing President ! Incoming President !

Position	Name	Mem. #	E-mail Address
President (3130)	Rajiv Gupta	33158320	rajiv.gupta@eil.co.in
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Secretary (3250)	Anuja Thukral	33173214	anuja.thukral@gmail.com
Treasurer (3350)	Arun Gupta	32929694	arung@indure.com
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Alt. Delegate (0030)	P P Patil	33137157	prashantpatil@ntpc.co.in
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Web Master (3420)	Radheyshyam Tiwari	33146408	radheytiwari@gmail.com
Exhibit Chair (0430)	H K Varshney	33117789	hemeshv@yahoo.co.in
Marketing Chair (1010)	R K Bassi	32941231	rkbassi@yahoo.com
Publications Chair (0970)	Sandeep Gupta	32899578	totalsolutionsco@yahoo.co.in
Honors & Awards (0510)	S Mahesh Kumar	32978456	s.mahesh.kumar@eil.co.in
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Section-Division Liaison (2850)	Sachin Joshi	33282834	sachin.joshi@eil.co.in
Standards & Practices (1150)	S K Dutta	33080949	skdutta@ntpc.co.in
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Sh. M P Singh
President Elect

Smt. C Saroj
Vice President

Ms. Anuja Thukral
Hon. Secretary

Sh. Arun Gupta
Treasurer

Sh. Ravinder Goyal
Society Delegate

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Sh. P P Patil
Alt. Delegate

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Program chair

Sh. S Sudershan Rao
Education Chair

Sh. Anil Chaudhary
Membership chair

Sh. Manish Kumar
Newsletter Editor

Sh. Radheyshyam Tiwari
WebMaster

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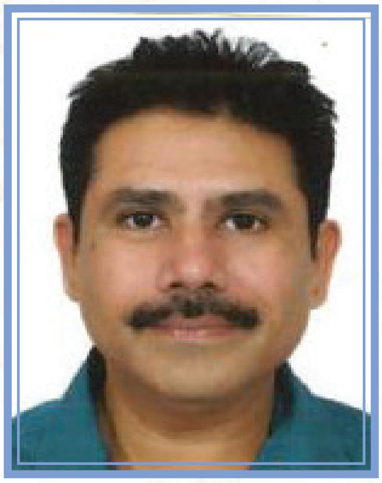

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Marketing Chair

Sh. Sandeep Gupta
Publication Chair

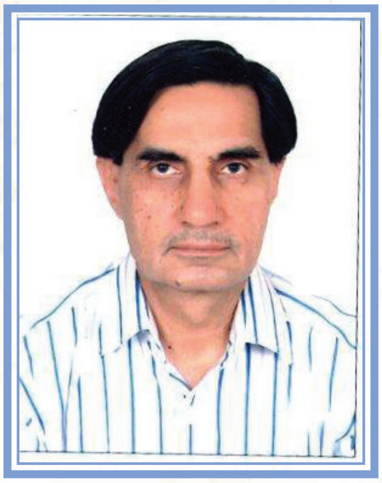
Sh. S Mahesh Kumar
Honors & Awards

Sh. Aman Sagar
Historion

Sh. Gaurav Jain
Student Section Liaison

Sh. Sachin Joshi
Section Devision Liaison

Team ISA Delhi



Sh. S K Dhawan
Sr. Advisor

Sh. H K Varshney
Exhibit Chair

Sh. S K Bardhan
Past President

Smt. R Priyamvada
Sr. Advisor

Sh. N K Pande
Sr. Advisor

Sh. R G Dhalwani
Sr. Advisor

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Sh. Alok Shrivastava
Sr. Advisor

Sh. S Samanta
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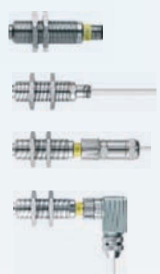

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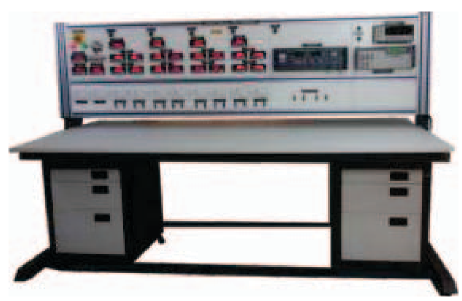

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Process Safety: Risk Analysis

Risk analysis in the petrochemical, metallurgical, pharmaceutical, food and energy industry etc.

Are you looking for an independent organization to carry out risk analysis for your company, in order to ensure a safe and statutory-conformant installation, whereby we jointly look for the most reliable solution for your design? In that case, Vincotte is undoubtedly your partner.

Your customized solution:

- Do you want to map the existing risks of your current process installation?
- Are you going to be constructing a new installation?
- Do you want to make major changes?
- Do you want to carry out a review/gap analysis of an existing risk analysis or new installation?

Vincotte would be happy to conduct the following risk analyses in collaboration with you, according to the type of project:

- HAZOP (Hazard and Operability Study)
- SWIFT (Structured What If Technique)
- FTA (Fault Tree Analysis)
- FMEA (Failure Mode and Effect Analysis)
- LOPA (Layers of Protection Analysis as per IEC 61511, Annex F)
- SIL (Safety Integrity Level as per IEC 61508 and IEC 61511)
- Bowtie (Bow Tie Analysis)
- ………

In what Situation?

Our service is primarily relevant to owners/operators, designers (engineering offices), suppliers and installers of process equipment.

For your specific situation, Vincotte has also the most appropriate solution. Contact us for a customized solution.

About Vincotte

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ISA Delhi Section

Program Details
Date-08th-09th April-2016
"Hotel Eros, Nehru Place, New Delhi"

DAY-1	8-Apr-16		Pg no.
Inauguration Session	Time		
Registration	08:30 AM	09:30 AM	
Arrival of Chief Guest	09:30 AM	9:45 AM	
Welcome of Dignitaries	09:45 AM		
Lamp Lighting	09:50 AM		
Welcome address by ISA-D president	09:55 AM		
Adress By Guest of Honour	10:00 AM		
Address by Guest of Honour	10:15 AM		
Adress By Guest of Honour	10:30 AM		
Address by Chief Guest	10:45 AM		
Release of Souvenir by Chief Guest	11:05 AM		
Vote of Thanks by Convener	11:10 AM		
Inauguration of Exhibition by Chief Guest and Dignitories	11:15 AM		
Networkig Tea Break	11:30 AM	12:00 PM	
Session-1 :	**12:00 PM**	**01:30 PM**	
1. End User Expectation and Automation Challenges in Oil Sector	IOCL	Mr. Sushanta Saha	185
2. Achieving Unified HMI through inter DCS operability	NTPC	Mr. R.Sarangapani Mr. Some Nath Kundu	92
3. Fundamentals of Wireless Communication and Future Trends	SIEMENS	Mr. Vivek Roy	168
4. IOT(INTERNET OF THINGS)	GE	Mr. Pankaj kumar Sharma	53

Networking Lunch Break	01:30 PM	2:15 PM	
Session-2	**02:15 PM**	**04:00 PM**	
Smart Quiz with special prizes	02:15 PM		
1. Fibre Optic Monitoring Solutions for Oil & Gas / Water Pipelines	HAWK	Mr. Subhendu Roy	77
2. Effective Measurement of Mercury in Power Plants Stacks"	CHEMTROL	Mr. Vijay Nair	138
3. "Non Contact Nucleonic Density Measurement using Sodium and Potassium source reducing hazard and security concerns"	EPT Russia	Mr. Vladislav	188
4. Measurement Technique for determination of Total Sulphur in fuels	Thermo Scientific Environmental & Process Monitoring	Ms. Jaya Nangia	121
Networking Tea Break	**04:00 PM**	**04:45 PM**	
Session-3	**04:45 PM**	**06:30 PM**	
1. Important Aspects SIS Design and recent development	BECHTEL	Mr. Arvind Sardhara, Mr. Sunil Bhandari & Mr. Subhro Sengupta	03
2. 3W and H of the Safety Requirements Specification	FLUOR	Mr. Amit K Aglave	41
3. Ensure Safer plant by on Line Partial Stroke Test of Emergency Shut Down valve	DRESSER,GE	Mr. Kajal Saha	22
4. Advance and reliable Fire & Gas detection in petroleum Industry	Honeywell	Ms. Arpan Bhattacharya	159
Lucky Dip - Day One	**06:30 PM**	**06;45 PM**	
FREE TIME TO VISIT THE BOOTHS	**6:45 PM**	**7:30 PM**	
Networking Dinner	**07:30 PM**	**10:00 PM**	
Day-2	**9-Apr-16**		
Session-4	**09:30 AM**	**11:00 AM**	
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3. Use of Advanced Optical Technologies (TDL and Raman Effect) for Gas Phase measurements in Refineries and Petrochemicals Industries."	Endress+ Hauser	Mr. Jiwan Jain	143
4. SMART City Concept	TECHNIP	Ms. Swati Dhawan Ms. Neha Singh	107
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Session-5	**11:45 AM**	**01:30 PM**	
Smart Quiz with Special Prizes	11:45PM		
1 Insight of the Challenges & the Steps to Improve Cyber Security for Industrial Control Systems	Wood Group Mustang (M) Sdn. Bhd.	Mr. Rahul Gupta	126
2 Cyber Security in COTS	NPCIL	Mr. Neeraj Agrawal	162
3 ESD system for Multiplant Complex project : Design & Implementation.	EIL	Mr. S. Bhowal	150
4 Industrial growth, Improved productivity, Efficiency, sustainability through advancements in Metrology	Isothermal Technology Private Limited,	Mr. Sandeep Sharma	85
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Session-6	**02:15 PM**	**04:00 PM**	
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1 3D Volumetric Analysis : Open & Closed Stockpiles	EIP	Dr. Abhishek Goyal	29
2 High frequency Radar level measurement : Universal sensor	VEGA	Mr. Abhijit Sarathe	124
3 Smart Microchip Based Natural Gas Chromatographs for Calorific Value Measurement	SIEMENS	Mr. Manoj Singh	176
4 RVMS – Remote Vibration Monitoring System New Trend	FORBES MARSHALL	Mr. Yokosuka / Mr. Mukesh Vyas	155
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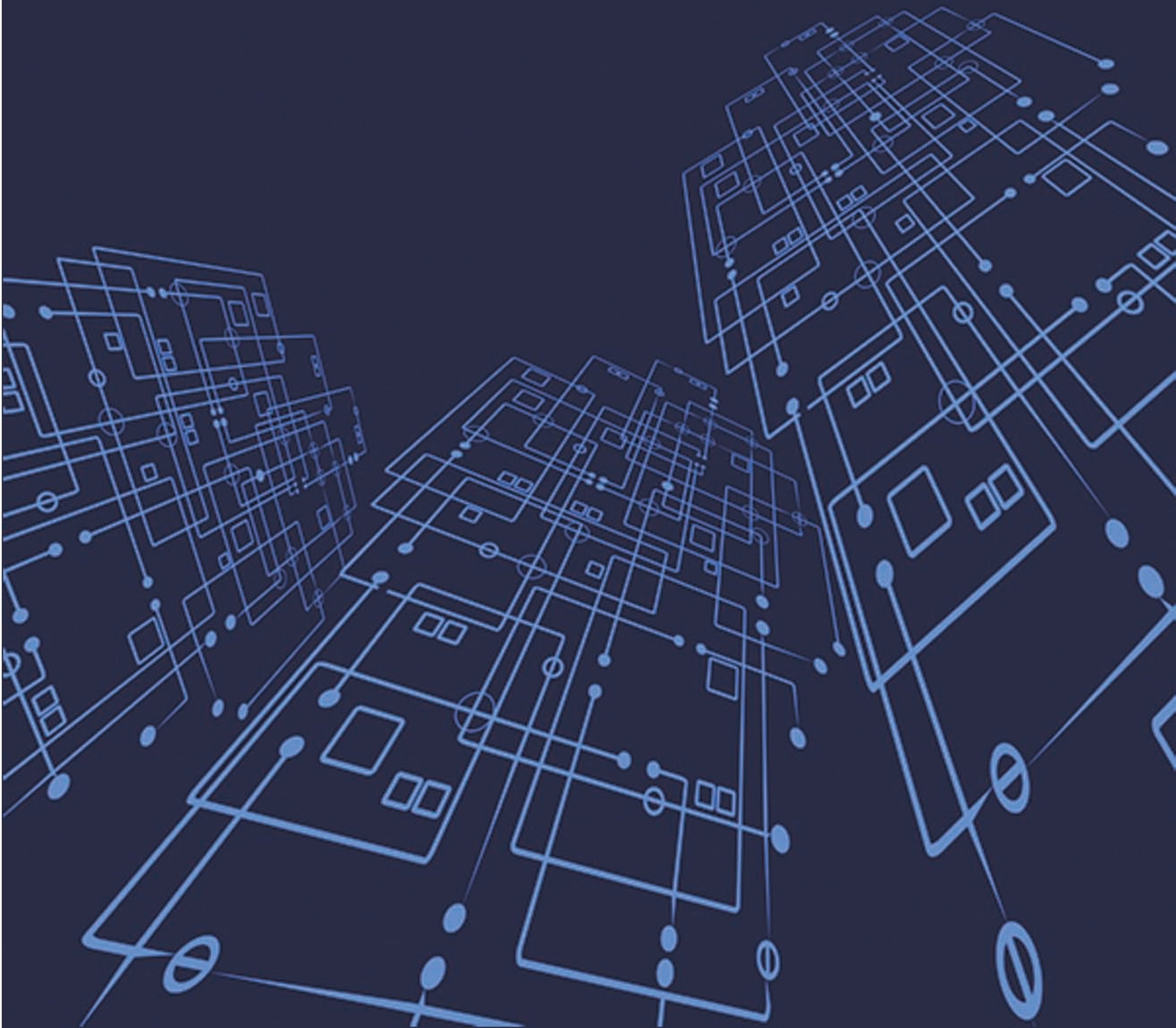
1 IOCL		Mr. Suresh Chopra	
2 EIL		Mr. Niraj Sethi	
3 ECIL		Mr. Noor Ahmed	
4 CHEMTROL		Mr. Nanda Kumar	
5 Bharat Electronics Ltd.			
Felicitations followed by Lucky Dip - Day Two	05:00PM	05:30 PM	
Networking Tea Break and END of the PPAM 2016	05:30 PM	06:30 PM	

Technical Papers



IMPORTANT ASPECTS OF SIS DESIGN & RECENT DEVELOPMENTS

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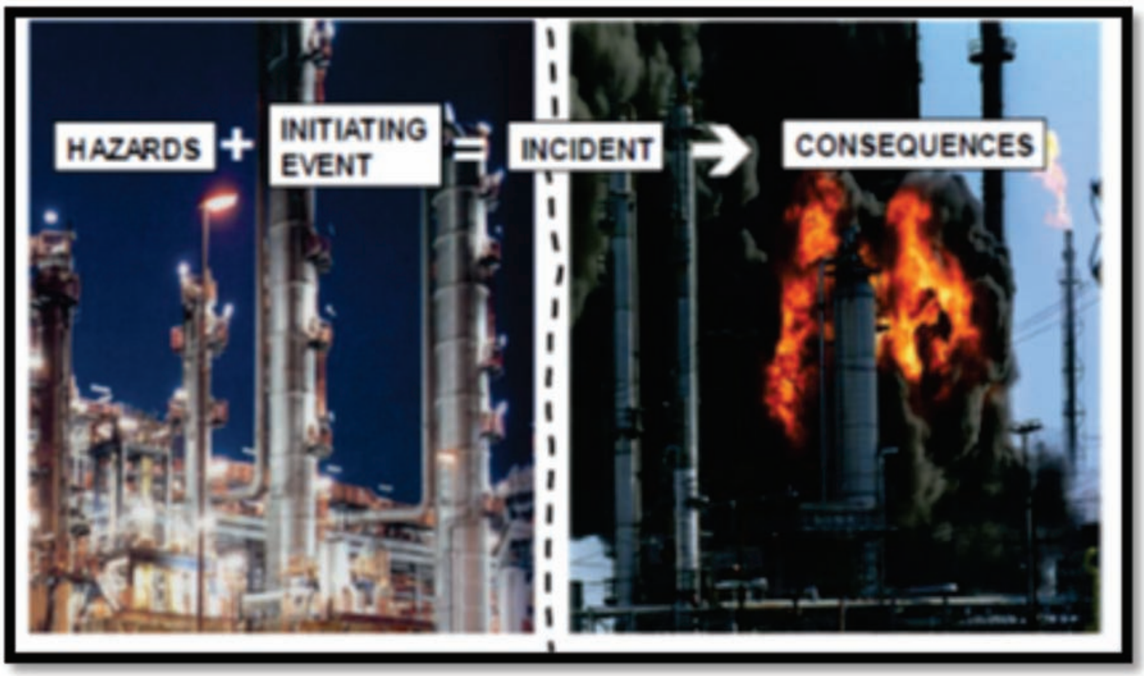
ABSTRACT

Safety Instrumented System (SIS) design needs careful and systematic approach to achieve desire result. This paper tries to capture various stages of SIS design for a refinery and important points to consider with examples and also recent development in IEC 61511.

Design of SIS follows Safety Life Cycle (SLC) approach and starts with Process Hazard and Risk Analysis and then allocating protection layers. Preparation of Safety Requirement Specification (SRS) is a very important step of design where safety interlocks, Safety Integrity Level (SIL) proof testing intervals, partial stroke testing, process safety time, startup/ maintenance bypasses and many other parameters etc. are specified. Subsequently logic solvers, field devices are chosen and verification study done. In verification study one needs to see target SILs are achieved and in doing so how proof test interval, hardware fault tolerance etc. effect SIL calculation.

KEYWORDS

Safety Life Cycle, IEC 61511, Common Cause Failure, SIL, Proof Test Interval, SIF, SIS, Diagnostic Coverage, Fault Tolerance, Partial Stroke Testing, Safety, SRS.



INTRODUCTION

In design of Instrumentation & Control, Safety plays a very important role while Process is playing with flammable materials, Toxic materials and extreme pressure & temperature conditions. Safety Instrumented System (SIS) is flexible and one of the most common engineered safeguards used in Refineries today. A Risk based systematic approach for designing SIS was undertaken for a Refinery Project as it yields superior designs with required risk reduction while minimizing cost. This paper discusses various important aspects faced during designing the SIS, other important aspects such as Installation, Commissioning, Operation and Maintenance etc. are not considered here.

DESIGN APPROACH

The following figure (Figure 1) describes basic design approach and standards referred for design of present SIS. There are certain myths which are being carried out from Projects to projects for example:

- Current methods must be safe because we have done this way for years without an accident;
- Following the standards involve more time-schedule and cost impacts;
- In my last project, which is identical in design, I had SIL 2 but now the same interlock is SIL 3 in my current project?
- It does not make sense to me. I have only one SIF -Why do I need all these FSMP, FSA..??
- Safety Instrumented System (SIS) is the responsibility of Control System and not for process, project engineering, process safety, electrical, mechanical etc.

We can see that design approach has to be comprehensive taking care of all concerns.

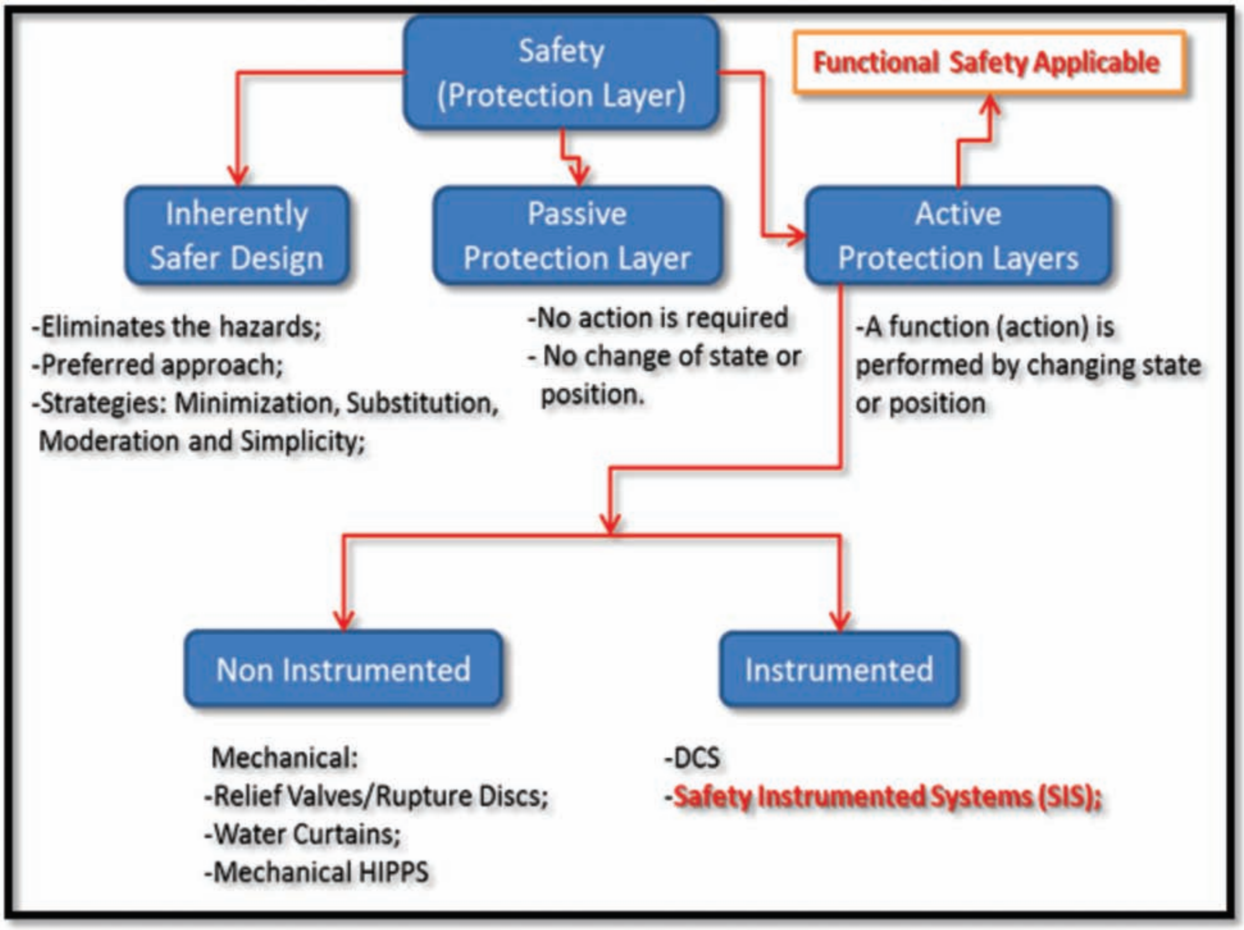


Figure 1 – Safety Tree

THE SAFETY LIFECYCLE:

The design of SIS starts with Safety Life Cycle (SLC) approach as mentioned in IEC 61511 (Figure 2).

The SLC is Cradle to Graveyard concept which comprises all the necessary activities to achieve high level of functional safety during conception, design, implementation, operation, maintenance, modification and decommissioning of the SIS. The safety life cycle is defined as an engineering process that includes all of the steps necessary to achieve required functional safety. The standard includes extensive documentation requirements and utilizes statistical techniques for the prediction of hardware failures. The standard focuses attention on risk-based safety related system design and requires significant attention to detail that is vital to safety system design. Various stages of SLC is followed in SIS design.

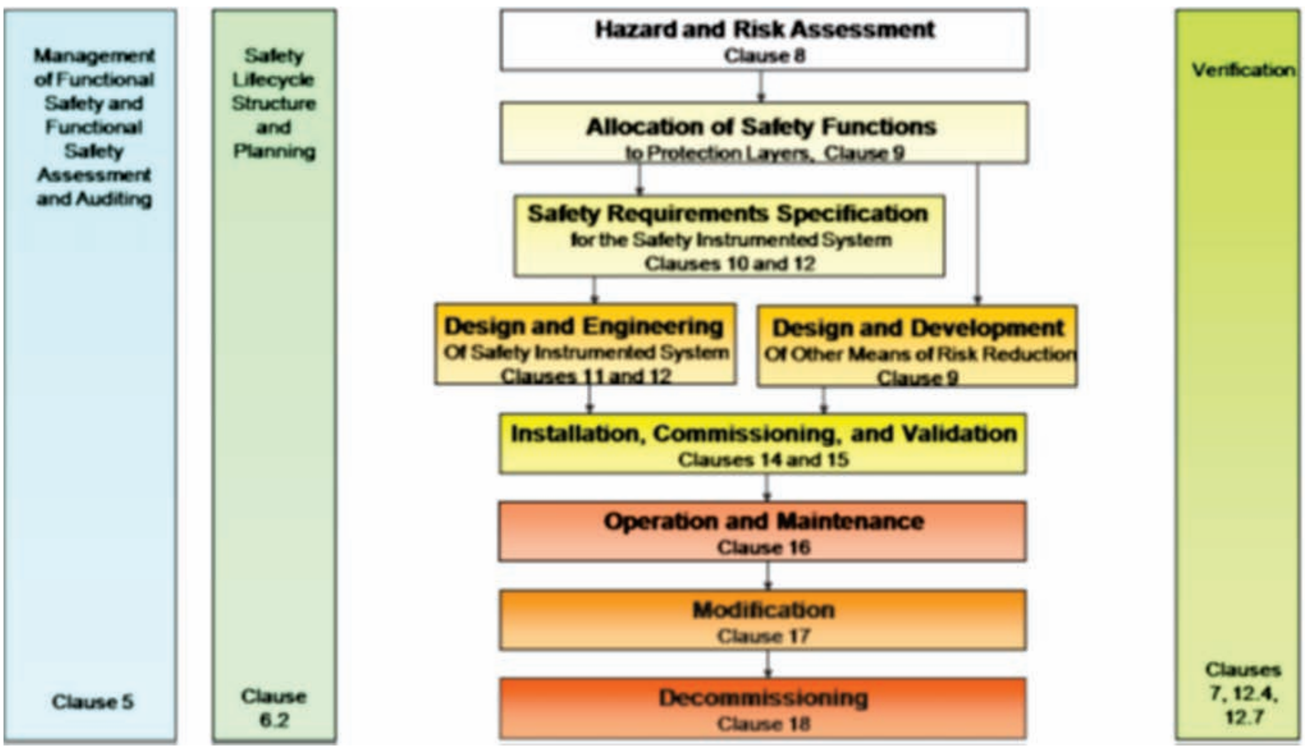


Figure 2 – IEC 61511 Safety Life Cycle

HAZARD AND RISK ASSESSMENT - IDENTIFICATION OF SIF

Based on Process Hazard Analysis Safety Instrumented Functions (SIFs) are identified which are required to protect against specific hazard. The SIF list for the project is shown herewith in Table 1. Identification of SIFs is performed considering a range of design documentation including Cause and Effect Diagrams, and Piping and Instrumentation Diagrams. The SIF List is defined with each SIF completely, including additional information such as interlock numbers, P&ID drawing numbers and any general notes for complete documentation purposes.

ALLOCATION OF SAFETY FUNCTIONS TO PROTECTION LAYERS - SIL STUDY/SELECTION

At this stage, the SIFs are analyzed sequentially looking at the hazards, identifying the appropriate perimeters that affect the risk of those hazards, and selecting an appropriate SIL to achieve a desired risk tolerance threshold. There are several methods (refer IEC 61151 -Part 3) to select the required SIL such as Risk Ranking Matrix, Risk Graph Analysis, Layer of Protection Analysis (LOPA). In the present case Risk Graph is applied and a sample of SIL study is shown in Table 2.

Interlock Number	SIF Mode Of Operation	Description	P&ID	Process Safe State	Interlock Test Interval	SPI Tag	Model	IO Type	I/O _System	Instrument Type	REMARKS
ESD-02-1	Low Demand	HIGH HIGH LEVEL (2oo3) IN MAKE-UP COMPRESSOR SUCTION DRUM MV-4X2221-V08 SHALL SHUTDOWN RECYCLE & MAKE-UP COMPRESSOR MC-4X2221-C01A/B/C	G41-4X2221-013	Shutdown of all compressors MC-4X2221-C01A/B/C as Products condenser can not cool the entire Reactor effluent. Resulting the high temperature in Compressor	4-years	2221LAHH 22	NA	DIS	DCS/ESD	HIGH HIGH LEVEL ALARM	FOR TRIPPING TWO OUTPUTS (1oo2) ARE WIRED DIRECTLY TO MCC AND ANOTHER VIA UCP. UCP OUTPUT TO MCC IS INITIATED FROM ESD OUTPUT (2221XS 203, 2221XS 205 & 2221XS J06).
ESD-02-1	Low Demand		G41-4X2221-013			2221LT 22A	MAGNATROL(X705-510A-A10	HART AI	ESD	LEVEL TRANSMITTER GUIDED WAVE RADAR	
ESD-02-1	Low Demand		G41-4X2221-013			2221LT 22B	MAGNATROL(X705-510A-A10	HART AI	ESD	LEVEL TRANSMITTER GUIDED WAVE RADAR	
ESD-02-1	Low Demand		G41-4X2221-013			2221LT 22C	MAGNATROL(X705-510A-A10	HART AI	ESD	LEVEL TRANSMITTER GUIDED WAVE RADAR	
ESD-02-1	Low Demand		G41-4X2221-015			2221XS 201	SIL3 CERTIFIED RELAY	DO	ESD	ESD OUTPUT TO MCC (EXISTING)	
ESD-02-1	Low Demand		G41-4X2221-015			2221XS 203	SIL3 CERTIFIED RELAY	DO	ESD	ESD OUTPUT TO UCP (EXISTING)	
ESD-02-1	Low Demand		G41-4X2221-015			22AGXA 030	INTERPOSING RELAY	DO	UCP	UCP OUTPUT TO MCC (EXISTING)	
ESD-02-1	Low Demand		G41-4X2221-016			2221XS 204	SIL3 CERTIFIED RELAY	DO	ESD	ESD OUTPUT TO MCC (EXISTING)	
ESD-02-1	Low Demand		G41-4X2221-016			2221XS 205	SIL3 CERTIFIED RELAY	DO	ESD	ESD OUTPUT TO UCP (EXISTING)	
ESD-02-1	Low Demand		G41-4X2221-016			22AHXA 030	INTERPOSING RELAY	DO	UCP	UCP OUTPUT TO MCC (EXISTING)	
ESD-02-1	Low Demand		G41-4X2221-34A			2221XS J05	SIL3 CERTIFIED RELAY	DO	ESD	ESD OUTPUT TO MCC	
ESD-02-1	Low Demand		G41-4X2221-34A			2221XS J06	SIL3 CERTIFIED RELAY	DO	ESD	ESD OUTPUT TO UCP	
ESD-02-1	Low Demand		G41-4X2221-34A			2221XA Q25	INTERPOSING RELAY	DO	UCP	UCP OUTPUT TO MCC	

Tag Nos. / ID	Role	Possible Causes of Demand	Integrity Assessment	Assessment Assumptions	Integ Level	Actions	Other Remarks
Refinery Project							
Colour Code:	Rose fill – NR / SIL4	Red fill – SIL3	Light Orange fill – SIL2	Yellow fill – SIL1	Bright Green fill – mechanical protection	Grey fill – Outstanding action or query.	Red text – there is a problem with this function. Bright green text = there is other protection.
P&ID No:				P&ID Title:			
C&E No:				C&E Title:			
XX-LITXXXA HH XX-LITXXXB HH XX-LITXXXC HH (2oo3)	Detects high level in the off-spec crude oil tank and causes total production shutdown to prevent overfilling tank to flare system and	Refinery shutdown with continued inflow from source.	Cb, Fa, Pb, W2	Overfilling puts oil to flare KO vessel and demand on its LAHH. Any rise in pressure lifts PSV and relieves to bunded area, gas release to atmosphere. 1 person, V=0.01. Flare drum LAHH trips plant but does not prevent PSV lifting.	SIL 1	Check possibility of back-pressure in overfill line to flare and hydrostatic head causing PSV to lift and potential	Assessment assumed back-pressure can lift PSV.
		Refinery shutdown with continued inflow from source.	Cb, Pb, W2	Liquid spill contained in bund, vapour release towards city.	EIL 1		
		Refinery shutdown with continued inflow from source.	Cc, Pb, W2	Cleanup of tank bund and re-certify PSV. Production down for 2 days @ $7m/day.	AIL 2		

Table 2 – SIL Study Sheet

SIL - Safety Integrity Level EIL – Environment Integrity Level AIL - Asset Integrity Level

SAFETY REQUIREMENTS SPECIFICATION (SRS)

The objective of the SRS is to define both functional and performance related requirements for the SRS. The SRS is prepared in enough detail that the functionality of the entire SIS (particularly the logic solver) is defined in sufficient rigor that detailed design engineering tasks can proceed (typically by a different group than prepare the SRS package). The IEC 61511 Section 10.3.1 provides a listing of the information that should be documented, or at least considered during this phase. Figure 3 captures the information in the listing:

Based on the above guidelines SRS is prepared. SRS contains two parts - one part contains general

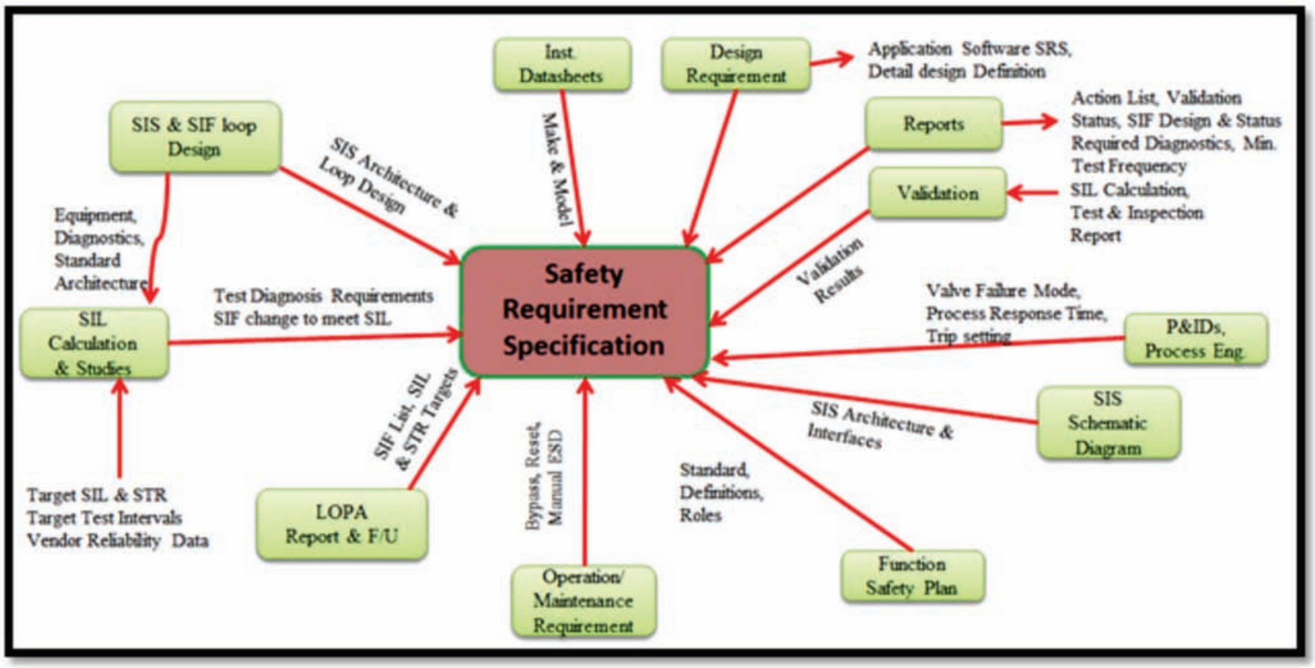


Figure 3 – Part of SRS

requirements as mentioned above and another part contains description of each SIF in the project. An example of a SRS sheet of a SIF is shown in Table 4 on last page.

SIS DESIGN AND ENGINEERING:

SIS design takes care of safety requirement specification. Requirements for operability, maintainability and testability are addressed during the design of the SIS in order to facilitate implementation of human factor requirements in the design (for example, by-pass facilities to allow on-line testing and alarm when in bypass). Material Requisition of SIS is floated and vendor is selected. With vendor information for logic solvers/field instruments and SRS requirements, SIL verification is carried out, generally by third party.

SIL VERIFICATION

This stage is where verification that each of the required SILs has been achieved by the system that has been designed is accomplished. Verification SILs require following important points to be addressed:

COMPONENT SELECTION

The component selection process considers both Suitability for the selected application & Suitability for use in safety. In order for a device to be "suitable for safety", the user must either have successful "prior use" experience with the device or it must be manufactured in accordance with industry recognized standards for suppliers of Safety Instrumented System components; specifically IEC 61508. This is typically verified by an independent third party certification.

FAULT TOLERANCE

Fault tolerance is the ability of the SIS to be able to perform its intended actions (and not perform unintended actions) in the presence of failure of one or more of the SIS components. IEC 61511 Table 5 & 6 specify minimum fault tolerance requirement for various SIL levels. In the present SIL verification case hardware fault tolerance was not met initially as per Table 6 requirement. However, section 11.4.4 states that fault tolerance level may be reduced by one if hardware of the device is selected on the basis of prior use. Accordingly data was collected from the site for the device which was already in use, and thus meeting fault tolerance level.

FUNCTIONAL TEST INTERVAL

Functional testing of a SIF decreases its probability of failure, and increases its effective SIL, by effectively reducing the fraction of time that a SIF is in the failed state. When a test of a SIF is performed, any latent failures in the system are identified and subsequently repaired. Partial stroke testing is also used in many interlocks where proof test interval is too high or the full stroking of valve is not possible in the operating plant. For the present case Test interval is taken as - 4 years. Partial Stroke Testing also considered.

COMMON CAUSE FAILURES

In One of Project the following values of CCF have been assumed to be reasonably conservative and applied to PFDavg calculations:

- **CCF for Logic Solvers – 1.5%;**
- **CCF for sensing elements – 5%;**
- **CCF for final elements – 5 %.**

DIAGNOSTIC COVERAGE

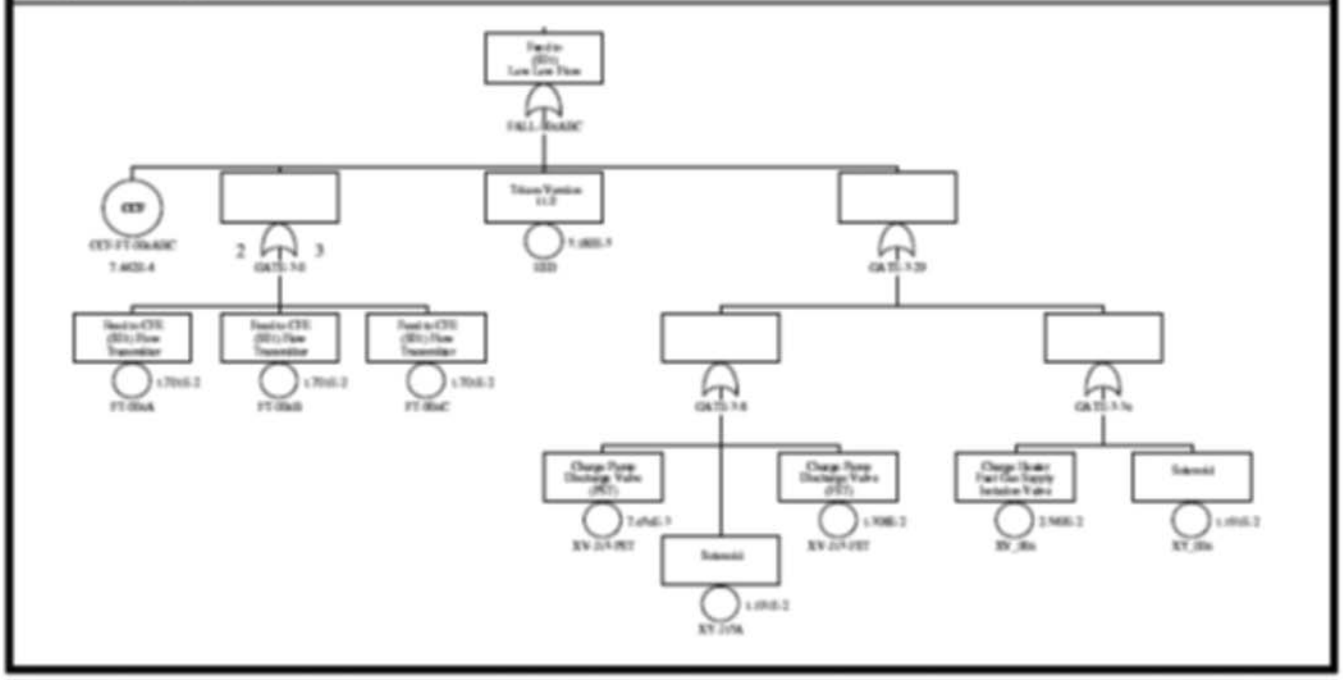
Diagnostics are essentially proof tests of an individual SIS component that occur rapidly and automatically, but only detect some of the potential failures of the device. The fraction of the failures that can be detected is referred to as the diagnostic coverage. Diagnostics decrease the overall probability of failure of a SIF by effectively reducing the dangerous failure rate. The following Fault Tree analysis was used in one of the refinery Projects.

Verification of SIL may require adjustment/changes in SRS and accordingly SRS is modified and issued to client to be followed.

CONCLUSIONS AND LESSONS LEARNT

SIS design is a continuous development process. While designing SIS for the project it is found that we need to take care of various aspects which play important roles such as Process Safety Time, Proof Test Interval, Partial Stroke Testing and Hardware Fault Tolerance. During the design of SIS, the Instrumentation Engineer should specifically ask Process group for the Process Safety Time well advance in time so that we do not have to change Actuator arrangement after finalizing the ESD Valve specification sheet. When there was no vendor data available we could use prior use data from client to meet target SIL requirements. With rapid advancement in technology many aspects of designing is possible now which was not possible in past.

Safety Availability (PFD_{avg}) Fault Tree Model



Safety Availability (PFD_{avg}) Cut Set Report

Cut No.	% Total	% Cut Set	Prob./ Freq.	Basic Event	Description	Event Prob.
1	35.55	35.55	2.55E-02	XV_006	Charge Heater Fuel Gas Supply Isolation Valve	2.55E-02
2	53.79	18.24	1.31E-02	XV-J15-FST	Charge Pump Discharge Valve (FST)	1.31E-02
3	70.40	16.61	1.19E-02	XY-J15A	Solenoid	1.19E-02
4	87.00	16.61	1.19E-02	XY_006	Solenoid	1.19E-02
5	97.68	10.68	7.66E-03	XV-J15-PST	Charge Pump Discharge Valve (PST)	7.66E-03
6	98.72	1.04	7.44E-04	CCF-FT-006ABC	CCF	7.44E-04
7	99.12	0.40	2.89E-04	FT-006A	Feed to CFE (S01) Flow Transmitter	1.70E-02
				FT-006B	Feed to CFE (S01) Flow Transmitter	1.70E-02
8	99.52	0.40	2.89E-04	FT-006A	Feed to CFE (S01) Flow Transmitter	1.70E-02
				FT-006C	Feed to CFE (S01) Flow Transmitter	1.70E-02
9	99.93	0.40	2.89E-04	FT-006B	Feed to CFE (S01) Flow Transmitter	1.70E-02
				FT-006C	Feed to CFE (S01) Flow Transmitter	1.70E-02
10	100.00	0.07	5.18E-05	ESD	Tricon Version 11.0	5.18E-05
		TOTAL PFD_{avg}:	6.97E-02			

Table 3 – Typical Fault Tree Analysis

UPCOMING CHANGES IN IEC 61511 2ND EDITIONS

It has been over 10 years since the first release of IEC 61511. A committee worked to create a 2nd edition. This will be published shortly in 2016. Here are some highlights of the new edition:

Clause 1: Scope

The "grandfather clause" – that only appeared in ISA 84 and not IEC 61511 – has been accepted by the IEC committee, although it was moved to clause 5 (on Management).

Clause 3: Definitions

The definitions for safe and dangerous failures (and many other terms) have been improved. In addition to demand mode and continuous mode, high demand mode has been added. The previous term of "proven-in-use" has been replaced with "prior use". The term and concept of safe failure fraction (SFF) has been removed.

Clause 5: Management of functional safety

New requirements have been added for suppliers. They must have procedures in place to demonstrate the adequacy of their functional safety management system, if they claim functional safety compliance to standard.

Clause 8: Process hazard and risk assessment

A new sub-clause state that a security risk assessment shall be carried out to identify the security vulnerabilities of the SIS and that it shall result in items called out in six bullet points and four notes.

Clause 9: Allocation of safety functions to protection layers

There is considerably more detail and cautionary warnings on the requirements for SIL 4 applications.

There are still clauses stating the risk reduction for a BPCS protection layer shall be ≤ 10, and if greater than 10 is claimed, the BPCS shall be designed and managed according to this standard. If the BPCS is the source of the initiating event, then no more than one BPCS protection layer may be claimed. If the BPCS is not the initiating source, then no more than two protection layers may be claimed.

Clause 10: SIS safety requirements specification (SRS)

Items such as requirements relating to proof test implementation are now clearly stated. There are many new excellent details to consider such as action to be taken on a sensor value out of range, excessive range of change, open and short circuit, etc. One should consider functions enabling proof testing and automated diagnostics tests of field devices performed in the application program.

Clause 11: SIS design and engineering

Since safe failure fraction is no longer used, the old Table 5 (in IEC 61511) covering the minimum hardware fault tolerance requirements for programmable electronic logic solvers no longer appears. One of the most significant changes to the standard is the single fault tolerance table that does appear. SIL 1 still requires a minimum hardware fault tolerance of 0. SIL 2 low demand also has a minimum hardware fault tolerance of 0. SIL 3 requires a fault tolerance of 1. In essence, the fault tolerance requirements for SIL 2 and 3 have been lowered by one compared to the first edition of the standard. However, this is a cause for concern and may be subject to potential abuse.

Clause 16: SIS Operation and maintenance

There is a new requirement to record the status of all bypasses in a log.

REFERENCES

1) IEC 61511- Functional safety :Safety instrumented systems for the process industry sector

2) IEC 61508 - Functional Safety of Electrical/ Electronic/Programmable Electronic Safety Related Systems

ACRONYMS

CCF	Common Cause Failure
DCS	Distributed Control System
DC	Diagnostic coverage

FSA	Formal Safety Assessment
FSMP	Functional Safety Management Plan
PST	Partial Stroke Testing
SIF	Safety Instrumented Function
SIS	Safety Instrumented System
SIL	Safety Integrity Level
SLC	Safety Life Cycle
SRS	Safety Requirements Specifications

BIOGRAPHIES

Arvind Sardhara is a Senior Control Systems Engineer working in Bechtel India since 2007. He has around 13 years of experience in Instrumentation and Controls related to Oil & Gas, Refineries and Chemicals.

Sunil Bhandari is a Senior Control Systems Supervising Engineer working in Bechtel since 1995. He has around 28 years of rich experience in Instrumentation & Controls related to Oil & Gas, Refineries and Petrochemicals. He worked in various national and international projects.

Subhro Sengupta is a Certified Automation Professional (CAP) from ISA working as Assistant Chief Engineer – Control Systems in Bechtel. He has more than 30 years of experience in Instrumentation & Controls related to Oil & Gas, Refineries and Petrochemicals in various national and international projects.

Definition Data Record Sheet							
Plant Area	Hydrogenation	SIF Title	Hydrogenation Reactor High Temperature Shutdown #1			SIF ID / Reference	SIF-01 Part #1 SD-1
P&ID	1000A/B1/B2			Comments			
Assigned Values		Safety SIL	1	Environ EIL	0	Asset AIL	2
Initiating Event:						Frequency of occurance:	
Hydrogen flow control loop failure						3.3 years	
Low flow caused by feed flow control loop failure						10 years	
Loss of cooling due to HE control loop failure						5 years	
1st bed inlet temperature control loop failure						10 years	
Consequence of un-controlled event: High temperature results in reactor explosion, possible multiple fatalities. Extensive damage to reactor and surrounding process equpment, production stops							
Control Description / Criteria for Successful Operation: **High temperature in each reactor bed is measured by 12 sets of 2oo3 thermocouples spaced throughout each bed. High temperature at any one location in any of the 3 beds shall cause shutdown #1. This is to account for localised runaway reactions and/or tunnelling through the catalyst. On initiation the following actions shall occur:** **• H2 supply is closed (XV-100A/B)** **• Interstage cooler outlets valves are fully opened (HV-600/1 A/B)** **• Interstage cooler bypass valves are fully closed (TV-600/1 A/B)** **This provides maximum cooling from the interstage coolers and continuing feed flow and also removes the supply of the reactants to prevent further reaction**							
Demand rate (Low <1/yr or High >1/yr)			Low	Rate	<1/year	Demands / year	
Plant Operating Mode(s)			SIF Active all of the time				
					Comments		
SIF Response Time requirement			3	Sec			
Target Proof Test Interval - Sensors			3	Years			
Target Proof Test Interval - Solver			5	Years			
Target Proof Test Interval - Elements			Various	Years	See comments for each element below		
Mean Time to Repair - Sensors			72	Hrs			
Max Time to Repair - Logic Solver			72	Hrs			
Mean Time to Repair - Elements			72	Hrs			
Manual Shutdown (Yes / No)			Yes	Where	Field	~~Local Panel~~	Control Room
Trip Latching (Yes / No)			Yes	Where	Logic Solver	~~Relay Panel~~	~~Field Device~~
Survivability & Other considerations: Surviveability is excellent providing there is no detonation. Furnace and associated isolation/purge valves could be destroyed dy detonation. Consider isolation valve location in design.							
Logic Solver: Yokogawa Prosafe RS							
Sensors: Bed #1 T-514A(B)-1-12A,B,C / Bed #2 T-517A(B)-1-12A,B,C / Bed #3 T-520A(B)-1-12A,B,C – Triplex Thermocouples at each of the 12 locations, additionally standby triplex TC's are available for switching online at each location, Transmitter Yokogawa - YTA320							
Tag	Fail Mode : Response		Voting	Detection		Safe State	Service
	High: Degrade to 1oo2		2oo3	High to Trip		Open Circuit	Reactor Bed
Bed #1 T-500A(B)-1-12A.B.C / Bed #2 T-600A(B)-1-12A.B.C / Bed #3 T-700A(B)-1-12A.B.C		Testing period for TC is 3 years Need to confirm response on failure, is the voting to degrade to 1oo2 or shall it switch to standby triplex TC, what if there is a failure in that one, then dergrade. Will a complete failure of all three TC's at a single location trip the system, or would production be switched to the standby reactor (if available)					
Failsafe wiring configuration (Yes/No)		Yes			Common Cause Failure Factor (Beta)		5%
Range	0 oC	550 oC	Alarm H		150 oC	Alarm HH	220 oC
Sensor Comments:							
Elements: **H2 Supply Valves, XV-100A/B - Metal Seat Ball Valves, Models of Valve, Positioner, Actuator and Solenoid to be confirmed when equipment selection is finalised** **Cooler Bypass Valves, TV-600/1A/B Butterfly Valves, Models of Valve, Positioner, Actuator and Solenoid to be confirmed when equipment selection is finalised** **Cooler Outlet Valves: HV-600/1A/B Butterfly Valves, Models of Valve, Positioner, Actuator and Solenoid to be confirmed when equipment selection is finalised**							
Tag	Fail Mode : Response		Voting	Action		Safe State	Service
	Closed: Trip		1oo2	Energise to open		De-energised	H2
H2 Supply, XV-100A/B		TSO required, Testing interval 5 years with PST every 6 months					
Tag	Fail Mode : Response		Voting	Action		Safe State	Service
	Open: Alarm		1oo1	Energise to close		De-energised	Reactor
Cooler Bypass Valves, TV-500/1A/B		Testing interval 3 months					
Tag	Fail Mode : Response		Voting	Action		Safe State	Service
	Closed: Alarm		1oo1	Energise to open		De-energised	Reactor
Cooler Outlet Valves: HV-500/1A/B		Testing interval 3 months, Cooler outlet valves are to be configured to prevent complete stoppage of flow, this can be achieved by minimum stop / undersized valve disc etc					
Failsafe wiring configuration (Yes/No)		Yes			Common Cause Failure Factor (Beta)		5%
Element Comments:							

Table 4 –Safety Requirements Specifications Sheet

SMART CITY CONCEPT & ROLE OF INSTRUMENTATION

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Abstract:

Smart cities are necessity of 21st century not only to reduce emissions, but to handle the rapid urbanization growth that the world is experiencing. Inefficiencies in urban areas bring large negative environmental and social impacts. City infrastructures are the backbone of the cities, delivering smarter solutions for a better tomorrow is an imperative need for implementation leading to the conditions for citizens to develop their professional, social and cultural activities. Infrastructures are also quintessential in guaranteeing the city's resilience to environmental risks.

The 3D components (Technology, Process and People) are dynamic in nature closely coupled with Information and Communication Technologies (ICT), innovative and intelligent monitoring system and various applications of smart process control system with advance predictive algorithms. We can achieve most competitive, efficient, cost effective and sustainable infrastructure where we can have judicious utilization of energy and natural resources.

Energy management, Transportation / Mobility, Sanitation, E-Governance, Traffic management, Water supply and Waste Water management, Solid waste management, Safety and Security, Environmental Sustainability as well as Building and Infrastructure management etc. can be implemented in Smart City. Smart City envision development of the process system closely integrated with Information and Communication Technologies (ICT) where these systems can share data with each other. Feeding this collected data from field devices to intelligent software applications and predictive control algorithms we can ensure judicious utilization of natural resources in SMART way.

This can be achieved by use of Advance Process Control Application and hardware like SMART wireless transmitters and metering, SCADA, PLC, Remote I/O's, and DCS automation with remote infrastructure management system, LAN / WAN, Wi-Fi.

Bechtel Corporation was involved in development and implementation of some of the Smart City applications worldwide such as King Abdullah Economic City - KSA, Jubail Industrial city & Riyadh Metro Network – Saudi Arabia etc.

This paper explores possible solutions for development and implementation of integrated solutions with specific focus on water and waste water management and recycling using security and communication networks. In the light of the best practices gained elsewhere in the world.

1. INTRODUCTION:

Rapid growth of urban population both natural and through migration, has put heavy pressure on public utilities like housing, sanitation, transport, water, electricity, health, education and so on. The urban population of India had already crossed the 217 million mark by 2011. By 2030, more than 50 per cent of India's population is expected to live in urban areas.

Cities are hubs of talent, innovation, and progress. Urbanization has been an instrument of economic, social and political progress. It has led to serious socio-economic problems. The magnitude of the urban population, haphazard and unplanned growth of urban areas, and a desperate lack of infrastructure are the main causes of such a situation.

This requires comprehensive development of physical, institutional, social and economic infrastructure. All are important in improving the quality of life and attracting people and investments to the City, setting in motion a virtuous cycle of growth and development. Development of Smart Cities is a step in that direction.

2. SMART CITY: CONCEPT, MISSION, VISION APPROACH: GOVERNMENT OF INDIA

There is no universally accepted definition of a Smart City. As per Wikipedia – *A Smart City is defined as the ability to integrate multiple technological solutions in a secure fashion to manage the city's assets which include, but not limited to, local departments information systems, schools, libraries, transportation systems, hospitals, power plants, law enforcement, and other community services.*

The Union Ministry of Urban Development, GOI is responsible for implementing the mission in collaboration with the state governments of the respective cities. To set forward this goal Government of India has recently published first batch of 20 cities in year 2015 which will be focused and developed as a role model to meet the demands of its rapidly growing and urbanizing population. So as to achieve this vision and mission approach of Govt. India has issued Mission Statement and Guidelines in June 2015.

3. IMPROVEMENT AREA AND CORE ATTRIBUTES FOR DEVELOPMENT OF SMART CITY

The major improvement areas of urbanization in India are - Urban Sprawl, Over-crowding, Housing, Unemployment, Slums and Squatter Settlements, Transport, Clean Water, Sewerage Problems, Trash Disposal, Urban Crimes and Problem of Urban Pollution.

The core attributes of Smart Cities / key pillars of a Smart City shown in figure 1.

Figure 1 Key Pillars of a Smart City, Source: KPMG Consulting ,2015

Smart cities are projected to be equipped with basic infrastructure and expected to offer a good quality of life through SMART solutions.

A Smart City must comprise mechanisms that ensure smooth functioning of all systems and processes within it. The six key elements motioned below are expected to make the city governance smarter:

1. Quality
2. Safety & Security
3. Services – Asset Management
4. Governance – O & M
5. Employment Generation
6. Sustainability - Economic, Social & Environmental

4 ROLE OF INSTRUMENTATION WITH ICT TECHNOLOGIES

The prime goal of instrumentation in context of SMART city is to improve system productivity, reliability, safety, optimization, and stability in any physical process applications. Instrumentation plays significant role in providing real time data with use of smart wireless network enabled sensors, transmitters, metering devices to real time control system components like SCADA, PLC's and DCS. These instrumentation components in consolidated way perform role of data concentrator and control centers for smooth operation and control of various process applications.

Since 1990s the field instrument and control systems underwent a dramatic change from analog devices to SMART intelligent digital devices to current SMART wireless and remote sensing devices which provide platform to innovate new solutions for upcoming SMART city applications which are already implemented as part of Smart cities initiatives.

Information and Communication Technology (ICT): -

Smart cities are considered "SMART" mainly from the point of view of their achievements in the field of ICT.

Integrating instrumentation and control systems with use of Information and Communication Technology (ICT) forms the backbone for next generation innovation and technologies. The objects like smart sensors and devices are integrated through wired and wireless networks to provide real time data to central control module. Further to this real time data processed with use of sophisticated analyzing software that delivers valuable information and digitally enhanced services to inter connected users.

Typical applications of ICT / instrumentation Technology in the Smart cities are:

1. Smart Meters for application like Energy, Piped Gas and Water Management
2. Smart Grid for optimization of peak loads and smart utilization of renewable energy such as solar panels and wind turbines etc.
3. Surveillance Systems with CCTV networks
4. Building Management Systems (BMS) to optimize the energy utilization (Lighting, Elevators) and HVAC systems
5. Availability of Wi-Fi enabled areas / hot spots for accessing real time data such as ATMs, Traffic patterns etc.
6. Smart parking systems to optimize driving time and retrieval and emissions in parking areas with use of sensors and Smart tags
7. Waste-bin trash collections using smart level sensors for better utilization of truck loads
8. Water and Waste management using smart instruments, SCADA etc.

Some of the Bechtel success stories in the way of implementation of new technologies in public domain in various application are noted as follows:

4.1 Jubail Industrial City, Saudi Arabia

Jubail is one of Bechtel's most remarkable achievement. Bechtel began work on the Jubail Industrial City project more than 30 years ago and is still working in Jubail now - a city built from the sand, requiring vast resources and logistical planning on an unprecedented scale.

The Smart instrumental solutions implemented with this project are:

1. Highways with traffic management systems
2. Railway networks for optimization of emissions and public mobility
3. Utilities like Power network and Water and Waste Water management

4.2 King Abdullah Economic City – Transforming the Kingdom

Saudi Arabia is moving forward with its long term economic development goal of diversifying its petroleum-based industries into other productive sectors, including manufacturing, ports, logistics, downstream products, and business centers. This transformation requires an ambitious infrastructure initiative that promotes private sector development, new sustainable cities and communities, and protected habitats.

Bechtel is working to develop King Abdullah Economic City, Core to the city planning and design is economic, social and environmental sustainability.

Following are some of the Smart Solutions using latest technologies:

1. Recycled water for irrigation
2. Adoption of solar power for heating and cooling
3. Urban sensors and analytics to optimize energy efficiency.

4.3 Riyadh Metro Network, Saudi Arabia

Riyadh's population of nearly 6 million is expected to increase to 8 million by 2030. The implemented metro system will meet the demands of the growing population while reducing traffic congestion and improving air quality.

So as to meet the needs of the growing population following smart infrastructure is implemented in this project:

1. Parking Management System which provides user information of available parking lot, capacity management and entry and exit control with use of Smart sensors and SCADA application
2. Energy / Building Management System Stations are powered by renewable energy

4.4 Hamad International Airport, Doha, Qatar

Bechtel provided engineering, project management, and construction management services for Hamad International Airport, completed in Qatar during 2014. Hamad International Airport replaced an existing facility, increased passenger and cargo-handling capacity, and accommodated the Airbus A380 super Jumbo Jets.

This sophisticated new airport accommodates 24 million passengers and 750,000 metric tons of cargo annually. It features following facilities which exhibits an excellent example of smart solutions:

1. State-of-the art air-traffic-control system
2. Security and Surveillance system
3. Energy / Building Management System Stations

are powered by renewable energy

5 WATER AND WASTE WATER MANAGEMENT FOR SMART CITY: AN INTEGRATED APPROACH

There are number of issues to be considered while reviewing a Smart City strategy in Indian context. Water and Waste Water Management is one of the biggest challenges ongoing with Smart City project implementation, addressing various key areas with innovative and smart instrumentation integrated with ICT technologies.

5.1 Current Scenarios and challenges with Water Management

Availability of water for domestic use constitutes one of the basic civic amenities. Unfortunately, in India there are only a few urban dwellers, who enjoy this amenity on a regular and satisfactory basis. Nearly 30 % of the urban population in India is deprived of safe drinking water facility. Largely, the municipal pipes and hand pumps are the major sources of procuring water in towns and cities.

Today we have reached a stage where practically no city in India which gets sufficient water to meet needs of city dwellers. In many cities people get water from the municipal sources for less than half an hour a day. In an analytical study conducted by the Delhi Committee of the Associated Chambers of Commerce and Industry (ASSOCHAM), it has been revealed that distribution losses of water are primarily due to leakages in a network of nearly 9,000 km-long water supply lines and because of theft committed in unauthorized connections. Water leakage and theft is largely to be blamed for the absence of piped water supply to large parts of the Capital as the total distribution losses are to the order of 40 %.

5.2 Integrated approach with automation for Water and Waste Water system

Most of the cities have a vast water distribution network for raw water supply running for serval kilometers covering sources from rivers, lakes, dams as well as ground water for raw water supply. These systems are currently operating in silo approach.

Whereas to balance demand side and available resources we need integrated systems which will have real time data and its analysis.

Smart solutions to address this issue using instrumentation are:

- Implement smart network of different type of instruments with real time data fed to central process and control unit with use of RTUs and PLCs.
- The processed data is further shared to multi-functional system where analysis and predictions can be made with advanced process modeling and simulators with geological mapping through use of ICT platform.

There is immediate need to have innovative, cost effective and sustainable solutions to resolve the issues stage wise. This can be achieved through the process of water extraction to water disposal and recycling/ reuse. Each stage has unique process and unified approach which can be implemented with automated solution with use of ICT tools.

It is possible to build fully automated system using step-by-step automated system application as follows

5.2.1 Pumping Station: Water Source and Extraction:

The important component in the conventional water system involves pumping stations which are mostly run in manual mode. Frequency of operation is on timely basis not as per requirement or on demand of overall system. There is no monitoring of equipment and planning for preventive maintenance due to high demand. Also due to overcapacity running frequent failure of these pumping stations are reported.

- Automate these pumping stations with remote node controllers which can be operated on the basis of overall demand and need of the distribution system. Which will save overall operation cost and saving electrical energy due to optimal use of pumping stations and equipment.

- The Smart solutions like asset management and equipment monitoring will provide overall health status of pumping equipment. To achieve this, we can plan timely preventive maintenance of these pumping stations so as to improve efficiency of equipment and reduce downtime of system.

5.2.2 Water Quality Analysis System for Water treatment and Purification Plants:

Since we are taking raw water from open source we need to process it before it is fed in distribution network. Various stages in this process include clarification, sedimentation, and chemical dosing.

- This overall process can be automated so as to obtain the water of a desired quality. Instrumented system like process analyzers with controllers can help to automate these processes. With use of analyzers like pH, Conductivity, Turbidity and Free chlorine.

- To obtain clean water with optimal use of dosing chemicals and equipment and maintain water quality parameters at desired level.

5.2.3 Smart Monitoring of Water Distribution Systems

The water in the supply network is maintained at positive pressure to ensure that it reaches all parts of the network, with sufficient flow at every take-off point. The water is typically pressurized by pumps that in to storage tanks constructed at the highest local point in the network.

Smart instrumented network with measurement of line pressure, flow and water quality at different points based on geological mapping we can have real time data of overall distribution network. So as to address following concerns

1. Geological mapping of overall system which will provide area based demand and demand patterns to form model for demand forecasting

2. Real time pressure and flow measurements Node based / loop based can help authorities to control leakages, illegal tapping and loss of water from system.

3. Online measurement of water quality parameter will help to monitor biological growth and physical changes (corrosion) in water line which causes chocking of water lines

4. Representation of system through mass conservation and energy conservation equations. Which will control intermittent booster pump based on system requirement. This can optimize the pressure so as to reduce loss of water in existing leakages and reduce the risk of bursting and breakages

5.2.4 Revenue Collection with Smart Metering

Revenue generation is most important part of any public domain system. The biggest challenges in water management system is metering and billing.

- Currently metering India is done manually which is prone to errors and resulting to overall loss of collection.

- The best solution with automated system is to build network with Smart and intelligent meters. It will also help operating agencies to collect user based consumption patterns, billing and collection of revenue.

This application will also improve overall system efficiency and proper utilization of clean water.

5.2.5 Automated Waste Water Treatment Plants:

According to central population board, India has an installed capacity to treat only about 30% of the household waste it generates and the rest is released into open drains or straight into the ground. If India were to widely deploy adequate treatment technology, the country would be able to significantly expand its available water supply, both for potable and non-potable use.

The process selection and design of waste-water treatment is dependent upon costs associated with treatment processes, including capital investment, operation and maintenance, land requirements, sludge handling and disposal and monitoring costs.

Waste-water treatment processes are characterized by continuous disturbances and variations that cannot be detected by manual measurements with the precision and within the time span necessary for maintaining proper operation of the facility typical process disturbances include process inputs and conditions such as variable flow rates, chemical and biological composition temperature and density.

- Application of automatic control and continuous online monitoring with Smart Instruments allows operator to control process variables well within permissible limits stipulated by the respective pollution control authorities.

6 CONCLUSION

In context of implementation of Smart city program, Smart instrumentation integrated with ICT plays significant and important role.

Similar solutions are implemented globally by various private and government agencies. Each of these Smart City solution and processes are unique based on geological location, overall people engagement, and implementation cost and policies frame work of the respective government.

The implementation of Smart Instrumented network which collects real time data from physical system, analyzing it through advanced process modeling and feed to connected user can be easily done with integrated approach and system. The same integrated system approach with Smart instrumentation can be developed for some of the public domain applications like Energy Management, Traffic and Parking Management etc.

Typical schematic diagram of integrated system is shown in figure 2.

Based on proposed solution of integrated system we can achieve effective and efficient utilization of available resources which will reduce overall load on the public domain system. Building a common integrated information and infrastructure covering various systems can be simulated based upon the structural model of Smart City and requirements of the implementing agency.

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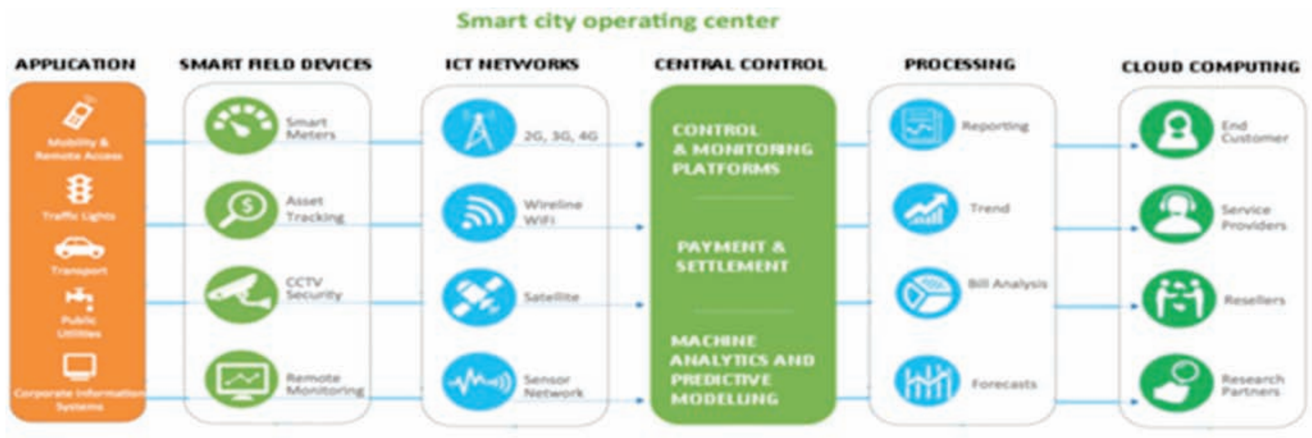

Figure 2. Smart City Operating Centre
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BIOGRAPHIES

Sh. Ravi Tata graduated from BITS Pilani in the year 1989 as Instrumentation engineer. He joined Indian Petrochemicals Limited (Currently RIL) as graduate engineer (GET). During last 20 years he is working with Bechtel India and his current role is Chief Engineer –I&C for Mining & Metals Global Business Unit as well New Delhi Execution Unit. As an Instrument Engineer he was involved in Engineering, Procurment and Construction of various projects world wide in Power, Oil & Gas and Mining & Metals sectors. He is also team member of Bechtel India associated with Smart City Council of India.

Sh.Abhijit Pathak graduated in Instrumtation engineering from JNEC Aurangabad (MH) in the year 2003 . He joined Orchid Chemicals & Pharmaceuticals Ltd. as graduate engineer (GET) . In his current profile he is working on global power projects with Bechtel India.During his carrer he has been associated with deatiled engineering and commissioning activities for control systems for various Process & Power Plants

Ensure Safer plant by on Line Partial Stroke Test of Emergency Shut Down valve

Kajal Saha, Dresser Valve India, GE Oil & Gas

Abstract :

The ultimate goal of any organization is to execute all activities efficiently and effectively to achieve a desired level of safety. To achieve this goal, it is important to ensure functional safety of the equipment in order to have a safer plant.

Safety instrumented system (SIS), commonly known as emergency shutdown (ESD), are required by standards IEC61508/61511 / ISA S84.01-2004 to be tested at a periodic interval based on HAZOP (hazard operation analysis) design to achieve and meet required safety integrity level (SIL). Traditionally SISs are functionally tested during turnarounds on yearly or once in two year basis. A major KPI for the industry is to maximize production, minimum downtime. This is forcing process industries to extend shutdown period from three to five years. This puts the onus on the final control element of the safety loop, which may remain untested for a longer time.

This paper will discuss testing the final control element of a safety instrumented function (SIF) loop, on-line, while the plant is running, by using a smart positioner to perform a partial stroke test to improve the reliability of these safety loops.

Keywords

Functional safety, Safety Instrumented System (SIS), Safety Instrumented Function (SIF), Emergency Shutdown (ESD), Safety Integrity Level (SIL), Final Control Element, Plant availability, Partial Stroke test (PST), Smart Valve Interface (Smart positioner), Diagnosis.

Introduction :

Due to increased awareness of plant operation safety, operational group of many industrial processes are providing stress on running plant safer and reliable with effective safe work process in place. Especially those in the chemical, hydrocarbon or oil and gas industries, involves inherent risk due to the leaking of dangerous chemicals or gases, needs extra care and safe measures. SISs are specifically designed to protect personnel, equipment, and the environment by reducing the likelihood or the impact severity of an identified emergency event. These safety systems involve final elements such as emergency shutdown valves, emergency venting valves, and emergency isolation valves, blow down valves, critical on-off valves, etc., which are generally operated by solenoid valve. These valves are not continually moving like a typical control valve, but are normally expected to remain static in one position and then reliably operate only when an emergency situation arises. Valves which remain in one position for long periods of time, due to process build up, are subject to becoming stuck in that position and may not operate when needed. This could result in a dangerous condition leading to an explosion, fire, and/or a leak of lethal chemicals and gases to the environment. To ensure the needed reliability and availability of these safety systems, they need to be tested frequently.

Unfortunately, the traditional method of testing these final element of a SIF loop requires plant shutdown, or alternatively the safety system to be rendered inoperable during the time, while the valves are being tested. These are both highly undesirable and very expensive options.
The traditional method of manually testing these safety valves involves a momentary movement generated by a technician. The technician observes movement and declares the test successful. This method does not provide any internal valve diagnostics. This method will not detect if the valve friction is increasing, process build up is occurring on bearing / shaft area or actuation pressure is decaying etc.

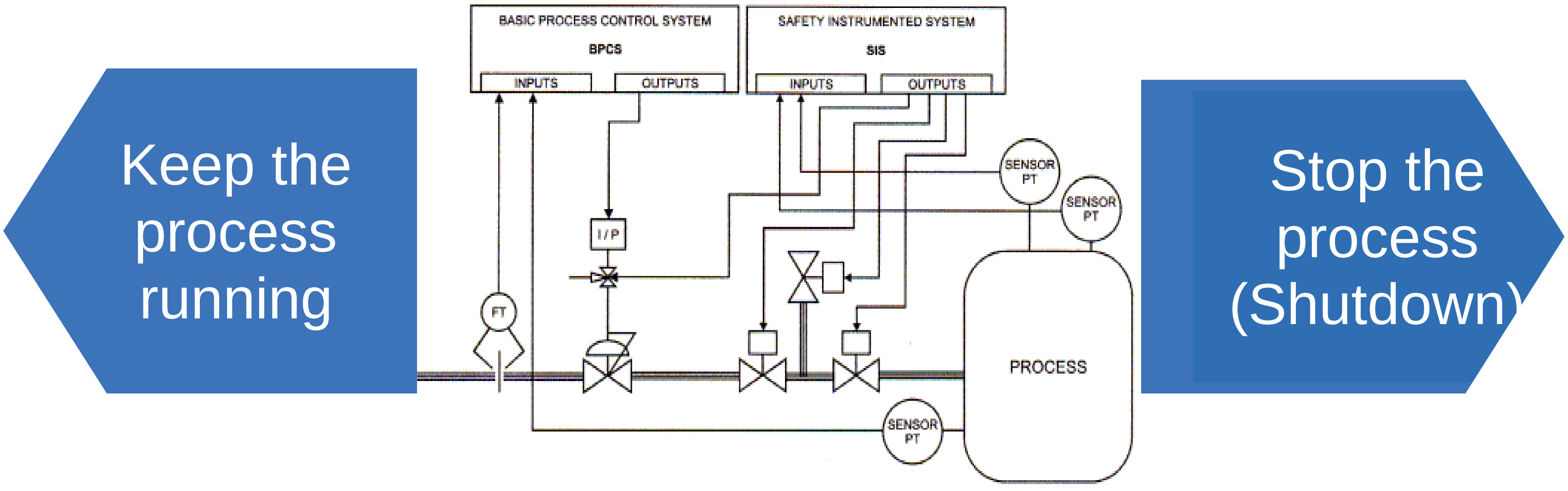
It is the purpose of this paper to review these safety concerns and diagnostics in detail for “final element” and then show how the use of Smart Valve Interface (smart positioners) can dramatically improve the reliability of these safety systems while significantly reducing the cost, as well as gaining a multitude of additional advantages.

The concerns

Testing to verify functional safety of a shutdown valve is a challenging problem, especially if testing must be done on-line. If a valve needs to be moved to 100% full travel, this can only be done on-line when a bypass valve is open. Alternatively the testing is done off-line typically during a major process shutdown / turnaround.

If a safety instrumented function is designed such that the valve can only be tested off-line and the time interval between tests is long, then safety integrity requirements drive designs toward multiple valves. This can be very expensive.

An alternative is to test the valve on-line, when process is running. This can be done manually if there is a bypass valve around safety shut down valve. The test procedure for the manual can be a bit complicated and every time the test is done, there is a chance that the bypass valve may be inadvertently left in the bypass position creating a dangerous situation. If the bypass valve is not in the bypass mode during the test, a false trip will occur, causing loss of production.



The solution – Smart Valve Interface to the rescue

A new microprocessor-based smart positioner has been applied to the on-line testing problem. These devices can automatically perform a partial stroke test, measure relevant variables of the valve and diagnose more potentially dangerous failures compared to traditional manual test methods. In addition these devices will respond to a process demand even during the middle of a test. Partial valve stroke testing can be done without using a bypass valve.

These smart positioners are communicating, microprocessor-based current-to-pneumatic instruments with internal logic capability. In addition to the traditional function of I/P and positioning, these devices use communications protocols such Hart, Foundation Fieldbus etc. to provide diagnostics details critical to process operation. The digital valve controller provides valve travel position, supply and actuator pneumatic pressures travel set point and input current values. This allows the smart positioner to diagnose not only itself, but also the valve and actuator to which it is mounted.

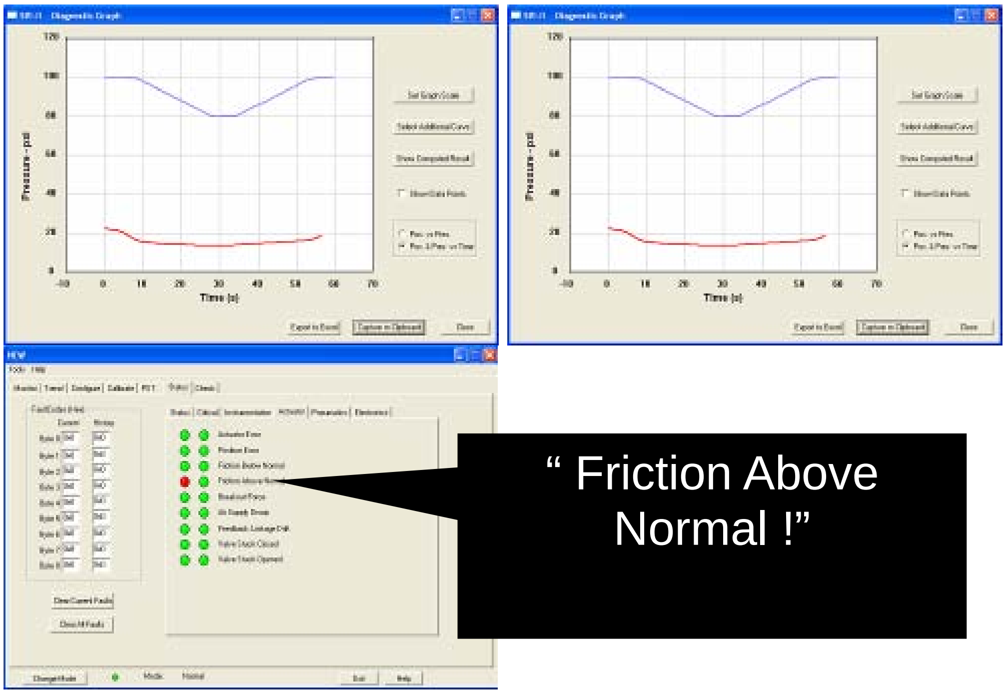
A smart positioner as part of the “final element” permits on-line partial-stroke testing of the valve and it also eliminates the need for special mechanical limiting devices or other special test apparatus.

Small valve movement (partial-stroke test) confirms the valve is working without disturbing the process. Testing can be done more frequently and flexibly due to automated system with built-in safe guards within the device. Because the test interval (TI) is inversely proportional to the PFD, more frequent testing has a dramatic effect on reducing the probability to fail on demand. Partial-stroke testing can be performed automatically with no operator attention required. This allows the TI to be as short as necessary (hourly, daily, weekly, etc.) to meet the target SIL values.

Many potential failures of safety shutdown valve can remain covet or hidden, if a valve is not exercised for a long time. A partial stroke test can possibly detect undetected dangerous failures, which would otherwise contribute to the PFD of the system failing in a dangerous manner.

Below listed are typical diagnostics partial stroke test can reveal:

- Increased packing friction over time
- Build up of process fluid material on shaft
- Seize of shaft in bearing
- Fracture valve shaft / stem
- Corroded bearing
- Broken spring of actuator
- Permanent set of spring
- Linkage breakaway friction
- Slow air exhaust
- Air exhaust path blocked
- Spring return actuator dented not allowing valve travel
- Increased valve break away friction
- Actuator stem / shaft bent
- Increased friction of closure element in seal



Typically the partial-stroke test moves the valve 10% from its original position but can be up to 30% if allowed by plant safety guidelines. Although partial-stroke testing does not eliminate the need for proof (full-stroke) testing (proof test is required to check valve seating, etc.) it does reduce the required proof test frequency to the point where it can most likely be tested during plant turnaround. Because the smart positioner communicates via protocol (Hart), the partial stroke test can be initiated from a Hart hand-held communicator, from a personal computer running the positioner companion software, or from a panel-mounted pushbutton hardwired to the positioner terminals.

Adding a smart positioner also permits remote testing thus saving time by reducing the requirement for maintenance inspection trips to the field.

Smart positioner provides diagnostic as well as positioning information, the valve status and response time can be monitored during the test. Valve performance trends are monitored and automatically analyzed after each partial-stroke test so that potentially failing valves can be identified long before they become unavailable. When used in conjunction with companion software, a step test can be run on the valve to determine overall stroking time. This test also can be used to analyze overshoot, dead band, and dead time.

The results of a signature test can be used to easily determine packing problems (through friction data), leakage in the pressurized pneumatic path to the actuator, valve sticking, actuator spring rate, and bench set. The digital valve controller can save the results of this data for printout or later use.

Overlaying the results of the current signature test with those of tests run in the past can indicate if valve response has degraded over time. This increases valve availability and ensures that the valve responds upon demand. It also reduces the amount of scheduled maintenance on the valve, because the tests can be used to predict when the valve needs maintenance.

As the smart positioner begins the partial stroke, it continually checks the valve travel to see if it is responding properly. If it is not, the digital valve controller will abort the test and alert the operator that the valve is stuck.

In short, a smart positioner can provide complete diagnostic health information on the final control element, including itself. In addition, the smart positioner can provide complete documentation of any emergency event as well as documentation of all testing. Insurance companies will accept this documentation for proof of testing. Best of all, this document can be completely automated so that expensive operator time is not required.

Smart positioners are smart enough to override partial stroke test, should emergency shutdown demand occurs during testing, driving the valve to its safe position and record the event for future study. (when positioner is operated by an analogue output signal of 4 – 20 mA).

Conclusion

Smart positioners provide performance and safety benefits through partial-stroke testing; many additional diagnostics benefits can be obtained to improve SIF loop reliability by continuous monitoring. Implementation of Smart positioner lowers base equipment cost, with considerable reduction in testing time and a reduced manpower requirement through the elimination of expensive pneumatic test panels and skilled personnel presently required for testing. Remote testing is key achievable benefit for microprocessor based controller, allowing testing for far-flung located valves.

Smart positioners are a great aid to predictive maintenance by providing a Valve degradation analysis, which is important for critical valves in safety related systems. This also reduces the amount of scheduled maintenance. While performing the partial-stroke test, if for any reason the valve is stuck, Smart positioners will not completely exhaust the actuator pressure. This assures that, should the valve become unstuck, it will not slam shut. These Smart positioners will then abort the test and send an alert signal to the operator warning that the valve is stuck.

The Smart positioner provides a time and date stamp on all tests and reports, which is very important for complying with the requirements of statutory authorities. It also provides the capability for comparing and interpreting diagnostic data.

Smart positioners allows partial-stroke testing while the process is running with no threat of missing an emergency demand. This type of test applies a small ramp signal to the valve that is too small to disrupt the process, but is large enough to confirm that the valve is working properly. Some digital valve controller also provides an inherently redundant pneumatic path. Should an emergency condition arise, the actuator pressure will always exhaust, either through the solenoid valve or through the digital valve controller itself, thus ensuring that the valve will always go to the safe position.

Smart positioners for performing partial-stroke testing, is a sensible and economically viable solution to ensuring the reliability of emergency shutdown safety systems.

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Biography

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He has worked in various roles in Control Valve Industry : Application Engineering, Sales & product marketing in India and Middle East & Africa with major focus in use of microprocessor base technology in final control element.

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3D VOLUMETRIC ANALYSIS
OPEN AND CLOSED STOCKPILES

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KEYWORDS

Coal fired power plant, Steel Plants, Mining Industry, Petrochemicals, PP, LDPE Plants, Coke Pit, Fertilizer Plants, Urea, Volume measurement, Bulk solids, Instrumentation, 3D Profiling, Lasers array of antennas.

ABSTRACT

Large-scale manufacturing industries ranging from power industry to cement to steel, plastics, foods, fertilizers and others must overcome challenges of accurately assessing and controlling inventory in the stockyard in order to successfully manage the entire production process. Hundreds of different kinds of powders and bulk solids around the globe of different shapes and sizes are stored in stockyards with widely varying basic characteristics Ð dielectric constants, particle size, particle type, chemical make-up of particles, and more. Conditions of storage are often harsh: they are dusty, impacted by extreme weather conditions, and subject to anomalies of irregular surfaces and unbalanced filling and emptying. They all present a great Challenge in knowing the its true level and volume, thus challenging the management in assessing and controlling it inventory, improve efficiency and preventing over spilling.

In this paper we will introduce a technology which employs an invisible Laser Scanner System to measure and map the entire surface area, and a patented algorithm that processes the information to generate a 3-dimensional map. The technology enables to measure the volume and mass of materials in new applications that other technologies cannot reach. It enables measuring practically any kind of material stored in an almost unlimited variety of containers, including large open bins, bulk solid storage rooms and warehouses. It enables mapping loads that randomly form over time inside silos, and many other previously inaccessible applications.

Providing much greater accuracy in its measurements and significantly enhanced overall performance, the technology represents very attractive solutions to continuous level & volume measurement challenges. The technology translates into major cost savings and faster returns on investment, and allows managers to make informed decisions that go right to the bottom line throughout the entire supply chain

INTRODUCTION:

The technology relates to monitoring of inventory and to process measurement, and, more particularly, to a system and method for measuring the contents of a stockpile. The monitoring of liquid inventory generally is straightforward. By contrast, the monitoring of bulk solid inventory that consists of particulates piled up often is very difficult. Examples of such bulk solid inventory include cement, coal, fly ash, iron ore, urea, coke etc. The measurement of the level of bulk materials in a stockpile is a problem that has not yet been solved adequately. The conditions in a stockpile are unfavorable (dust, extreme weathers, etc.) and the contents of the bulk material stored in the bins often do not have a flat surface and are not always isotropic. Other difficulties arise from the wide variety of bin shapes in use and from the explosive atmospheres.

The scope of the term ÒstockpileÓ as used herein includes any area, for bulk particulate solids, whose structure defines an interior volume for receiving and storing the solids. Such a stockpile be closed above, below and on all sidesor may be open above or on one or more sides

Four principal methods are known for continuous measurement of the content of a Bin/ Fly ash silo/ ESP Hoppers

(1) **Acoustic Devices** working on Acoustics having a beam angle of 70-80 degrees offer the advantage of wide coverage area and solves the problems related to dusty atmosphere. However, the coverage of 70 degrees calls for installation of multiple devices in a stockyard which makes the installation feasibility in question.

(2) **Theodolite based** system essentially consists of Angle measurements, some distance measurements manually and then assessment of the same by an expert mathematician. The calculations can only be understood by the person who is an expert. The method and calculations are prone to various errors and is also a very time consuming process.

(3) **Total Station** being a portable device to be carried to the field for measurement is also prone to manual errors and is significantly time consuming process and not feasible for all locations.

(4) **Radar level sensors** work on the principle of electromagnetic wave transmission and reception. The beam angle of the Radar level Sensor being only 6-7 degrees and since there is a delay in measurement Radars offer a practical difficultly in covering an entire stockyard or the system becomes too complicated to handle. Hence, Radars are generally preferred for Boom Height.

(5) **Ultrasonic Sensors** working on Ultrasonic Echoes offer the same principle of measurement and offer similar difficulties as in the case of Radar Level Transmitter with an additional disadvantage of being affected by dust.

All the prior real time sensors discussed above except the Acoustics are insensitive to the shape of the contents, and so are inaccurate in the presence of a common phenomenon of uneven profiling due to angle of repose that occurs in bulk particulate solids.

There is thus a widely recognized need for, and it would be highly advantageous to have, a method and a technology of measuring the content of a stockpile that would overcome the disadvantages of presently known methods as described above. In particular, it is not known in the prior art to map the upper surface of the contents in three dimensions.

METHODOLOGY/SUMMARY OF THE INNOVATIVE TECHNOLOGY Ð VOLUME MEASUREMENT OF THE STOCKPILE

The technology employs a 2-dimensional array beam-former to send low frequency pulses and receive echoes of the pulses from the contents of the silo, bin or other container. The device's Digital Signal Processor samples and analyzes the received signals. From the estimated times of arrival and directions of received echoes, the processor generates a 3-dimensional image of the surface that can be displayed on a remote screen.

The ARTEMIS¨ Scanner takes an average of **10500 point measurements** on a surface per individual scanning cycle and offers exceptional accuracies when utilized to quantify hard and soft bulk commodities.

The proprietary ART¨ and AIMS¨ software element of the ARTEMIS¨ solution **calculates volumes, publishes reports and provides a graphic interface**. The PC running this software is usually located on the clientsÕ network for easy distribution of data to all relevant personnel. Scan results are immediately available on completion of a scan cycle and no additional calibrations or calculations are necessary post scan as all ÒspikesÓ or irregular points were eliminated automatically by the software.

Three factors combine to make the technology an innovative one and the best-of-class solution for accurate measurement of bulk solids, particularly those in dusty environments:

1. Invisible Laser at 950nm that works in bright sun light.
2. The Laser Scanner with Angle measurements works in tandem to provide the Distance (Time of Flight), Horizontal Angle (Azimuth) and Vertical Angle (Angle of Elevation) which helps in defining the X, Y and Z coordinates of any point in the Stockpile to plot the exact 3D Profile along with Volume Calculations.
3. Proprietary algorithms enabling precise 3-D mapping of the contents in the Stockyard along with Confidence intervals of the readings which help the user

define the reliability of measurement in case of dust storms or other extreme weather conditions.

Few Advantages of the System

1 24 X 7 All day long Volume, Mass and 3D Profile of the Stockyard
2 Measurements are independent of Stockyard movement
3 Does not require any special encoder/ position tracker
4 Wireless transmission directly to control room and multiple locations through LAN
5 Uses Invisible Laser for Long Distances
6 Installation Plan allows for 100% coverage
7 Very Accurate and independent of in accuracies of the other associated systems
8 Laydown area programmed into software with confidence factor per block area scanned.
9 Virtual partitioning inside scan to allow for product segregation or focusing on key areas of a stockpile.

APPLICATIONS

- **Coal Fired Power Plants**
- **Steel Plants**
- **Cement Plants**
- **Fertilizer Plants**
- **Food Industry/ Storage Silos**
- **Alumina industry**
- **Chemical and Powder Industry**
- **Minerals industry**
- **Mining Industry**
- **Petrochemicals**
- **Warehouses**
- **Open Stock Yards**

METHODOLOGY/SUMMARY OF THE INNOVATIVE TECHNOLOGY ĐVOLUME MEASUREMENT

Artemis 3D Laser technology actually takes advantage of the 360 degree rotation and uses proprietary algorithms to add another important dimension, **direction**. The result is that every scan the Artemis 3D Laser receives a matrix of around 10,500 x-y-z position coordinates that represent the echoes from the surface of the contents in the stockpile. Connecting these points together generates a highly accurate profile of the surface area, which in turn yields more precise measurement of the amount of materials being stored.

Method of Algorithm: How to find and detect the direction from which the echoes are coming from:

Step1: Every echo reflected back goes through classification algorithm.

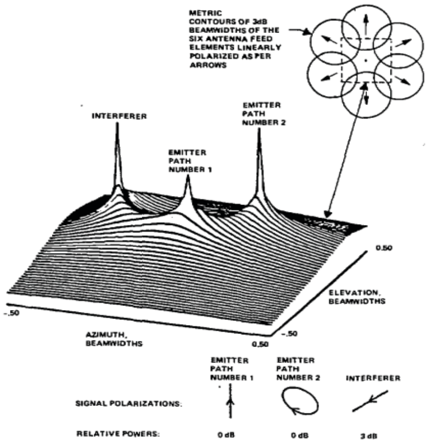
The MUSIC (MUltiple SIgnal Clasification) algorithm: is a linear subspace algorithm that achieves performance close to Shanon limit with relatively low complexity cost. MUSIC estimates the frequency content of a signal or autocorrelation matrix using an Eigen space method. This method assumes that a signal, x(n), consists of p complex exponentials in the presence of Gaussian white noise. Given an $M \times M$autocorrelation matrix, $\mathbf{R}_x$, if the Eigen values are sorted in decreasing order, the eigenvectors corresponding to the p largest Eigen values spanning the signal subspace. Note that for M = p + 1, MUSIC is identical to Pisarenko's method. The general idea is to use averaging to improve the performance of the Pisarenko's estimator. The frequency estimation function for MUSIC is

$$\hat{P}_{MU}(e^{j\omega}) = \frac{1}{\sum_{i=p+1}^{M} |\mathbf{e}^H \mathbf{v}_i|^2},$$

Where $\mathbf{v}_i$are the noise eigenvectors and

$$e = \begin{bmatrix} 1 & e^{j\omega} & e^{j2\omega} & \cdots & e^{j(M-1)\omega} \end{bmatrix}^T.$$

Example of Music algorithm result with 2- dimensional array



The algorithm records the exact time that every pulse is transmitted and the exact time every adjacent echo is received. The difference between these times is the time of flight of signal. The distance is the time of flight multiplayer by half the propagation speed (half because the signal travels forth and back).
The Speed of sound is given by

$$331.3\sqrt{1+\frac{T^{\circ}}{273.15}}$$

T is the measured temperature in Celsius.

For every direction of echo there is a specific set of relative phases induced on the scanner array. However there are some directions that create the same phases on the array even though the directions are not the same.
That effect can be avoided if the spacing between array elements is not more than half wavelength.

Step 2: Angle Calculation

When the spacing between array elements is larger than half wave length there are some different pairs of angles (θ1,φ1) and (θ2,φ2) that cannot be distinguished physically by the array. The smallest angle θ0, such that for every pair of spherical angles that fulfill θ1<= θ0 and Θ2<= θ0, the directions (θ1,φ1) and (θ2,φ2) induce different relative phases on the array (thus every two directions with smaller θ can be distinguished) is the maximal angle at which the array can figure direction without aliasing mistake. In triangular array this angle is given by:

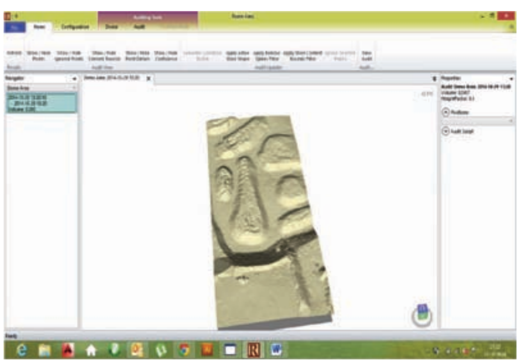
$$\theta_0 = a\sin\left(\frac{C}{\sqrt{3}\cdot f\cdot D}\right)$$

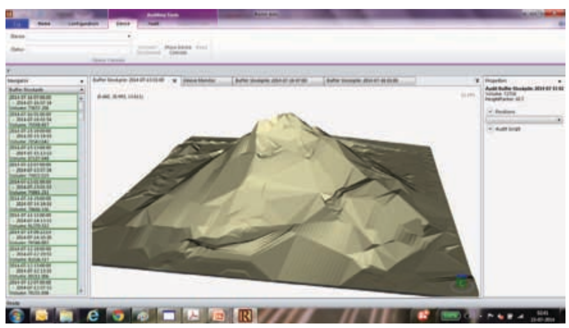
Where:
D is the spacing between antenna elements.
C the propagation speed
F pulse carrier frequency

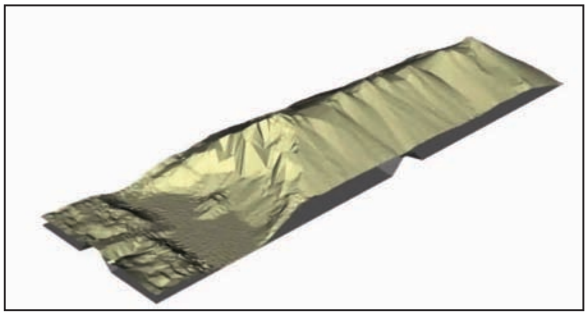
RESULTS

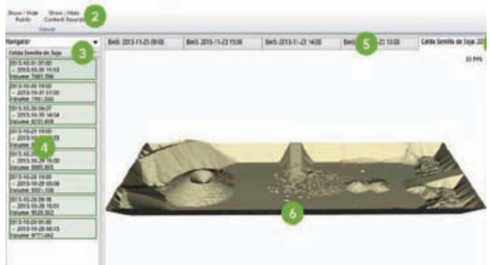
Using the described technology results:

(1) In the ability to profile bulk solid materials in silos such as the below examples:

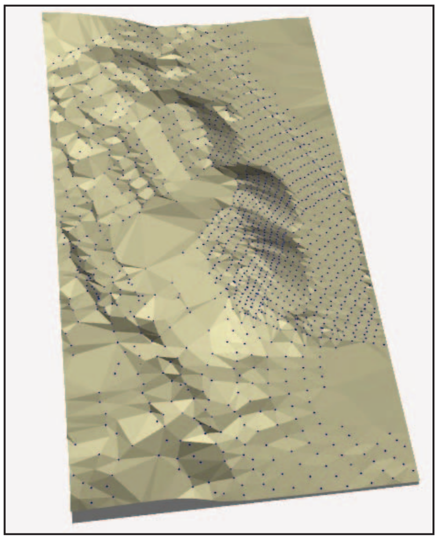








(2) The ability to reach unprecedented volume accuracy. The accuracy reached with the described technology:



CONCLUSION

The results show a great improvement in the accuracy of measurement in bulk solid applications

Comparing today's technologies with the described technology shows an improvement in the volume accuracy by an order of magnitude.

Therefore, it is advisable for customers from a variety of industries (steel, power, cement, food, chemicals) who wish to asses more accurately the amount of materials they have for inventory purposes and optimization of manufacturing process to use the suggested technology.

Providing much greater accuracy in its measurements and significantly enhanced overall performance, the technology represents a revolution to continuous level & volume measurement challenges. This translates into major cost savings and faster returns on investment, and allows managers to make informed decisions that go right to the bottom line throughout the entire supply chain of their plant.

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NON CONTACT NUCLEONIC DENSITY MEASUREMENT USING SODIUM AND POATASSIUM SOURCE REDUCING HAZARD AND SECURITY CONCERNS

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KEYWORDS

Density Measurement, Power Plants, Steel Plants, Mining Industry, Slurry, Liquid,

Nuclear, Na-22, Radioactivity

ABSTRACT

Large-scale manufacturing industries ranging from power industry to cement to steel, plastics, foods, fertilizers and others must overcome challenges of accurately measuring the liquid density. There are many technologies for measuring the same namely, Conventional Nucleonic Density Measurement, Coriolis based, Microwave based, Ultrasonic based and Gravimetric based. However, all the technologies have their limitations with major affects being the temperature, pressure, vibration, damage and suspended solids but the technology that has really stood the test of time is Nucleonic Density Measurement. However, with the stringent restrictions on the import and use of radioactive sources (Cs-137 and Co-60) for the conventional nucleonic technology has faced its hardships in the past.

In this paper we will introduce a Nucleonic technology which used Na-22 and K-40 as the radioactive sources. The density meter uses gamma radiation of the radiation free source of Na-22, the natural background or gamma radiation of chemical potassium compounds with the natural concentration of the isotope K-40. Due to its principle, these devices do not exceed the minimum significant activity level pursuant to the existing IAEA radiation on safety standards and regulations. These devices do not generate any radiation background, do not require ant special radiation shield, do not pollute the environment and can be used for typical applications without restriction on temperature, pressure and suspended solids.

TYPES OF DENSITY MEASUREMENT

Coriolis

Coriolis density meters, also known as mass flow meters or inertial flow meters, work on the principle of vibration to measure phase shifts in the vibration of a bent thin walled tube. The bent thin walled tube is rotated around a central axis. When there is no mass in the bent section, the tube remains untwisted. However, when the density inside the bent section increases, the inbound flow portion of the bent pipe drags behind the out flow portion. This twisting causes phase shifts which result in changes in the resonant frequency of the thin walled tube. Therefore, the resonant frequency is directly affected by the density. Higher density media causes a larger coriolis effect. Flowing media causes a frequency phase shift at both ends of the bent pipe. This is proportional to the mass flow rate of the sample.

Coriolis meters measure the mass flow of the system. They do not measure the volumetric flow. However, a volumetric flow can be inferred from the mass flow measurement. These measurements are restricted to small diameters for flow tubes. However, this measurement technique results in high accuracy and high repeatability. Coriolis meters also have a fast response time. Coriolis meters need to be calibrated for temperature and pressure. The zero points for these values are used to calibrate the system. Coriolis meters cannot be calibrated while in use. The span difference is used to see how temperature and pressure have changed.

Microwave

Microwave density meters have various ways to measure what solids are in the sample. All microwave meters measure microwaves but some use different methods such as measuring the microwave propagation speed change, amplitude reduction, time of flight, single phase difference, or dual phase shift. Each technique has certain accuracies.[1]

Some microwave meters use a ceramic probe that is directly inserted into the sample. This allows the meter to have direct contact to the sample in question. However, this limits the types of slurries and sludges that can flow through the pipe line. Abrasive slurries with particulates can damage the sensor probe. Microwave meters are also limited to liquids with unvarying dielectric constants. The percentage of solids of the slurry affects the dielectric constant for the entire sample. Typically, percent solids greater than 20% result in large errors. Similar inconsistencies happen with large pipe diameters.

Microwave meters are very good at detecting dissolved solids. Homogenous solutions are easily seen by microwave meters. This makes them a fit for applications where the solution is consistent and non-abrasive.

Ultrasonic

Ultrasonic density meters work on various principles to calculate the density. One of the methods is transit-time principle (also known as the time of flight principle). In this technique, two transducers are mounted to the sides of the pipe walls. The transducers alternate between sending and receiving ultrasonic signals. From this transit time measurement, the flow velocity and volume flow based on the diameter of the pipe are calculated.[2]

Another method this is used is ultrasonic attenuation method. This method measures the count of various signals with certain amplitudes. The density of the media flowing through the pipe affects the signal sent through the pipe. This changes the strength of the signal, causing a weaker signal and smaller amplitude.

Another method that is utilized in ultrasonic meters is the envelope energy average method. This method is based on not only the amplitude of the signal but also the shape of the signal. These packets of information are called envelopes.

Doppler ultrasonic meters measure the suspension flow where the concentration of solids in the slurry is above 100ppm and the particles that are suspended are larger than 100 microns in diameter. However, the Doppler method only works on concentrations of less than 10% solids.

Gravitic

Gravitic density meters work on the principle of gravity to calculate the density of a sample. A flexible hose is used to determine the change in weight. Using the principle of beam deflection of two fixed ends, the weight can be calculated. Increases in weight result in a larger deflection. Decreases in weight result in a smaller deflection. The volume inside of the hose never changes. Since the volume is constant and the weight is known, the density is easily calculated from this information.

Displacement is measured with a high precision displacement laser. Micron scale deflections can be read by the density meter. Minute changes in weight are seen at this scale.

The entire volume is measured using gravitic methods. This means that the sample size is the entire volume of what needs to be measured.

Nuclear

Nuclear density meters work on the principle of measuring gamma radiation. Gamma radiation is emitted from a source. This source is typically Cesium-137 (half-life: ~30 years). The radiation is seen by a scintillator device. The radiation is converted into flashes of light. The number of flashes of light is counted. Radiation that is absorbed by the mass is not seen by the scintillator device. Therefore, the density of the media is inversely proportional to the radiation captured and seen by the scintillator.

Conventional Nuclear density meters are limited in scope to what is seen by the gammaradiation beam. The sample size is a single, thin column with small longitudinal length.

Conventional Nuclear equipment requires certified and licensed staff in order to operate the instruments.

DISADVANTAGES OF CONVENTIONAL NUCLEAR DENSITY MEASUREMENT

- Uses Highly Active Radioactive Source of Cs/ Co
- Radioactive Activity Very High and dangerous for people and environment
- Emission is higher that the levels pursuant to current IAEA radiation safety standards and regulations
- Significant Radiation Background
- Special Heavy Protection casing for background Radiation
- Pollutant to the environment
- Special training required to handle the instrument
- Dismantling and Disposal is a significant problem
- AERB Certification and Import License for each import

NUCLEAR DENSITY MEASUREMENT WITH NA-22 SOURCE AND HIGH SENSITIVITY DETECTOR

The technology used in the device consists of natural or artificial gamma radiation sources emitting 1 -20 micro Curie (with Maximum Source Radioactivity of less than 1 MBq) which does not exceed the minimum significant activity level pursuant to the *existing IAEA radiation safety standards and regulations therefore the devices are not subject to the supervision by the State Nuclear Supervision Authority, Sanitary Epidemiological Service. Moreover, the device is not subject to licensing by AERB as the Source Na-22 and the radioactivity level is under the exempted category allowing for an NOC for the sourec import.*

In contrast to its conventional Radio-isotopic analogues, the device uses natural and artificial gamma radiation sources which activities do not exceed the minimum significant activity levels pursuant to the applicable IAEA radiation safety standards and regulations.

Emitter/ Radiation Source

In various applications the gamma radiations of the radiation-free source of Na-22, the natural background or the gamma radiation of chemical potassium compounds with the natural concentration of the isotope Potassium-40 are used.

These devices have all advantages of traditional radioisotope analogs, namely they are indispensable in difficult process conditions when used for:

- toxic, aggressive and biologically hazardous materials;
- corrosive and abrasive substances;
- molten and cryogenic materials;
- radioactive substances of high or alternative activity;
- foams, slurries and sludge;
- powder and other highly dispersed free-flowing substances;
- pulp, ore, feed stock and other similar materials;
- vessels without pressure restrictions;
- vessels without temperature restrictions.

These devices are free from the main disadvantage of traditional radioisotope

analogs, i.e. necessity to use a powerful radionuclide source.

Following are special features our device:

- Natural Sources of Na-22 and K-40 with very low activity (less than minimal significant activity-MSA)
- do not generate a radiation background;
- do not require a special radiation shield;
- do not pollute the environment;
- do not require specially prepared and certified premises and personnel;
- do not create problems during dismantling of the equipment.
- Do not require special heavy protection casing

Due to the absence of a radiation source or its small dimensions (there is no radiation protection) the devices can be mounted in the places where it is impossible to install conventional devices.

The non-contact density meter do not contain moving parts and do not require maintenance. You really can "plug and forget".

3W’s and H of Safety Requirements Specification

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Fluor Daniel India Pvt. Ltd.

ABSTRACT

The application of the Functional Safety Standards such as IEC 61508 and IEC 61511 to process industry nowadays has become a standard norm. As per the definition in IEC 61511, “Safety Requirements Specification (SRS)” is a specification that contains all the requirements of the Safety Instrumented Functions (SIFs) that have to be performed by the Safety Instrumented Systems (SIS). As the definition suggests, this is a very vital document in the SIS Safety life-cycle and forms the basis for the SIS design.

Unfortunately, this key document is often developed to merely meet the requirements of the standards or to complete the documentation as per the agreed document deliverables list. This specification document is often delayed and issued very late in the life-cycle when most of the SIS design and development has already completed. Rather, the SIS design should be based on the SRS.

The intent of this paper is to answer the ‘3W and H – Who, What, When and How’ for the development and application of SRS specification in SIS design. These 3W and H questions are to identify the requirements and assign the responsibilities:

a. Who – Who should develop the SRS,

b. What – What should be the content of the SRS,

c. When – When should be the SRS developed and

d. How – How to ensure the correctness of the SRS.

KEYWORDS

Functional Safety, Safety Lifecycle, Safety Requirements Specification, Safety Instrumented System, Safety Instrumented Function, Safety Integrity Level.

INTRODUCTION

The foundation of development of great products or systems depends on how the required details are specified.

The functional safety standards IEC 61508 and IEC 61511 lay down the guidelines for the determination of specific safety requirements for correct development and deployment of systems used for safety applications. IEC61508 applies to the ‘Functional Safety of Electrical/Electronic/ Programmable Electronic (E/E/PE) Safety Related Systems’. IEC61511 applies to ‘Functional Safety - Safety Instrumented Systems for Process Industry Sector’.

The critical information identified during a qualitative hazard analysis such as Process Hazard Analysis (PHA) is further applied to identify the safety requirements necessary to avoid the hazards. Further, the technologies to be applied to reduce the risk of the hazards are identified. The risk reduction to be achieved with the help of the E/E/PE bases safety related systems depend on the identification of the Safety Instrumented Functions (SIFs) which are designed specifically to avoid a particular hazard. The risk reduction to be achieved by each SIF is determined and assessment of the integrity requirements of the SIF is expressed in terms of

Safety Integrity Level (SIL).

It is a well established fact that most of the failures of the control systems can be attributed to the incorrect specifications. The HSE – UK findings published in “Out of Control – Why Control Systems Go Wrong and How to Prevent Failure” suggests that 44% of failures are attributed to inadequate specifications (12% due to inadequate functional requirement specifications and 32% due to inadequate safety integrity requirements specification).

Hence in order to achieve intended functional safety, it becomes imperative to ascertain that the Safety Requirements Specification is adequately defined to cover the functional and integrity requirements of the SIS.

Safety Lifecycle

IEC 61508 combines various phases of the project in to Safety Lifecycle (refer Figure- 1 below). Each phase is defined in the standard and provides the basis for structured approach for each of the phase of the safety lifecycle.

One of the key phases of the safety lifecycle is defining the Safety Requirements Specification as shown in box 9 in Figure- 1 below.

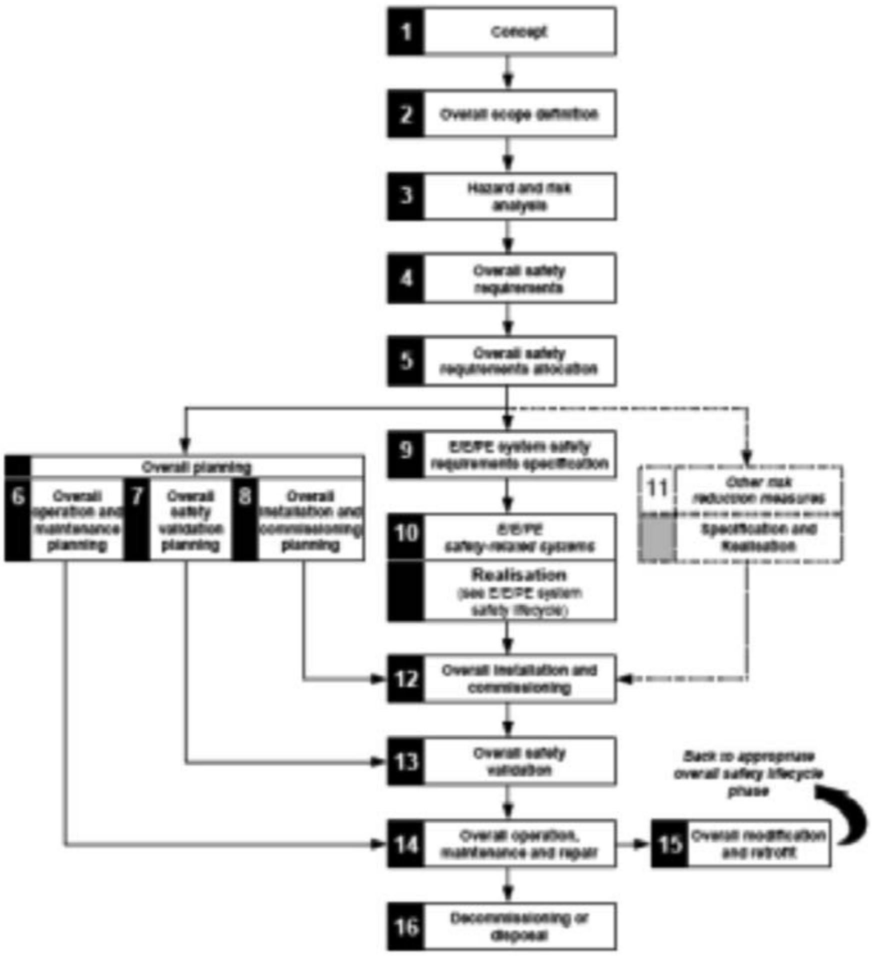


Figure- 1: IEC 61508 Safety lifecycle phases

IEC 61511 also provides a similar lifecycle which is applicable to the deployment of the SIS to the process industry (refer to Figure- 2 below).

The IEC 61508 standard is a generic standard and mostly applied for the development of the products which are used in the safety related applications.

The IEC 61511 standard is applied when the products which are designed in accordance to IEC 61508 are used in process industry as part of SIS for achieving functional safety.

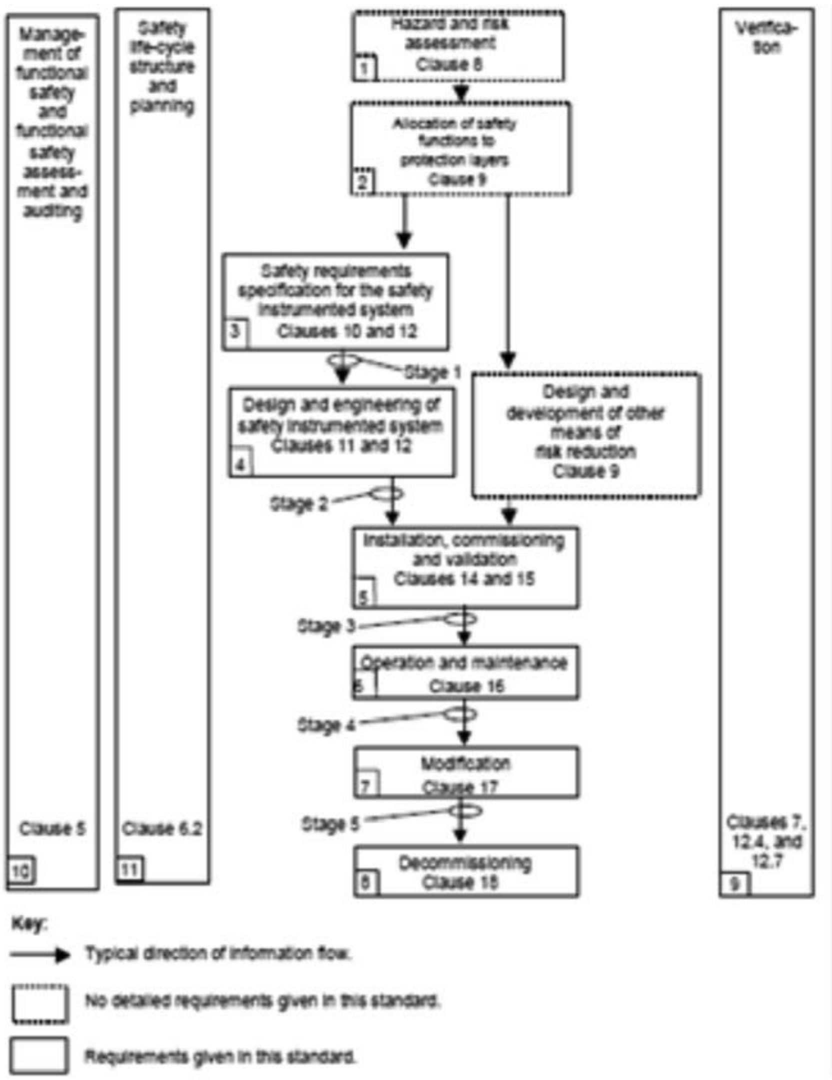


Figure- 2: IEC 61511 SIS Safety lifecycle phases

SRS - SAFETY REQUIREMENTS SPECIFICATION

Both IEC 61508 and IEC 61511 standards define the objectives of the 'Safety Requirements Specification'.

The objective of SRS as defined in IEC 61508 is to specify the E/E/PE system safety requirements in terms of E/E/PE system 'safety function requirements' and E/E/PE system 'safety integrity requirements' in order to achieve the required functional safety.

The objective of SRS as defined in IEC 61511 is to specify the requirements of the 'safety instrumented function(s)'.

This paper is intended to cover the requirements of the IEC 61511 which are applicable for the deployment of the SIS for the process industry.

The SRS should be developed in such a way that it clearly list out the design requirements of the SIS with respect to the following:

- The Functional and Integrity requirements. The functional requirements cover what should the SIS configuration with respect to hardware and software so that it meets the requirements for risk reductions. The integrity requirements address the reliability requirements of the SIS.

- It should establish the interface requirements with other systems such as supervisory computers (HMI), software and hardware interactions for operation and maintenance.

- It should list down any constraints, limitations so that SIS effectively manages risk in the operation and maintenance phase.

Theoretically, the SRS is developed after the allocation of the SIFs to the protection layers. It is a common perception for the engineers deploying SIS that the SRS is a single document which need to be generated one time before the design and engineering of the SIS begins. However, SRS development is not a onetime document preparation nor it is a single document. Since the SRS has to provide both functional and integrity requirements, this information is spread out in different documents which are used for the configuration of the SIS.

Since the standard itself has provided brief information about SRS, it is observed that each project, organization has derived different meanings for SRS. Based on the available budget, schedule and contractual requirements, either a SRS is developed or a collection of documents are pointed to referring as SRS.

3W's and H of the SAFETY REQUIREMENTS SPECIFICATION

To clear out the ambiguity in the preparation of the SRS, it's important to understand and answer the basic questions of Who, What, When and How for SRS.

a. Who – Who should develop the SRS

- The intent of this is to assign the responsibility to a person or a department within or outside the organization involved in the development of SRS.

b. What – What should be the content of the SRS

- The intent of this is to identify the minimum content of the SRS necessary to development, deployment and maintenance of the SIS.

c. When – When should be the SRS developed

- The intent of this is to ascertain the timings of the associated activities.

d. How – How to ensure the correctness of the SRS

- The intent of this is to ascertain that the developed SRS has been adequately specified to indicate the risk reduction to be achieved.

Let's look in detail each question to establish the criteria for development of SRS to properly specify the design requirements of the SIS.

Who – Who should develop the SRS:

Functional Safety is a complex subject. The successful design and development of the SIS relies on the correct development of the SRS.

The earlier phases of the SIS safety lifecycle such as Hazard and risk assessment, allocation of safety functions to protection layers see the involvement of multi-disciplinary team such as Process, Risk Management, Health and Safety Engineering (HSE), Mechanical and Instrumentation. Also, the participation in this phase is from personnel from various backgrounds such as engineering, maintenance and operations.

However, when it comes to the development of the SRS, it is often observed that the SRS is developed by Instrumentation or Control System engineers with little help from other disciplines.

The Management of Functional Safety requires identifications of persons, departments and organizations which would be necessary to carry out each phase of SIS safety lifecycle.

Development of SRS also should be a multi-disciplinary activity. There are certain parameters or documents which comprise SRS can be better defined by the HSE or process or operations rather than instrumentation personnel. The involvement of electrical personnel is also equally important. It is often noticed that the SIFs are developed and allocated SIL which involves trip of the electrical equipment to achieve the intended safety, but the electrical personnel are unaware of this fact and have not chosen the appropriate components to meet the SIL of the SIF.

If the design of the SIF involves special requirements, the involvement of specialist in the development of the SRS is must. For example, the High Integrity Pressure Protection System (HIPPS) implementation, the SRS should be either developed or reviewed by the HIPPS specialist.

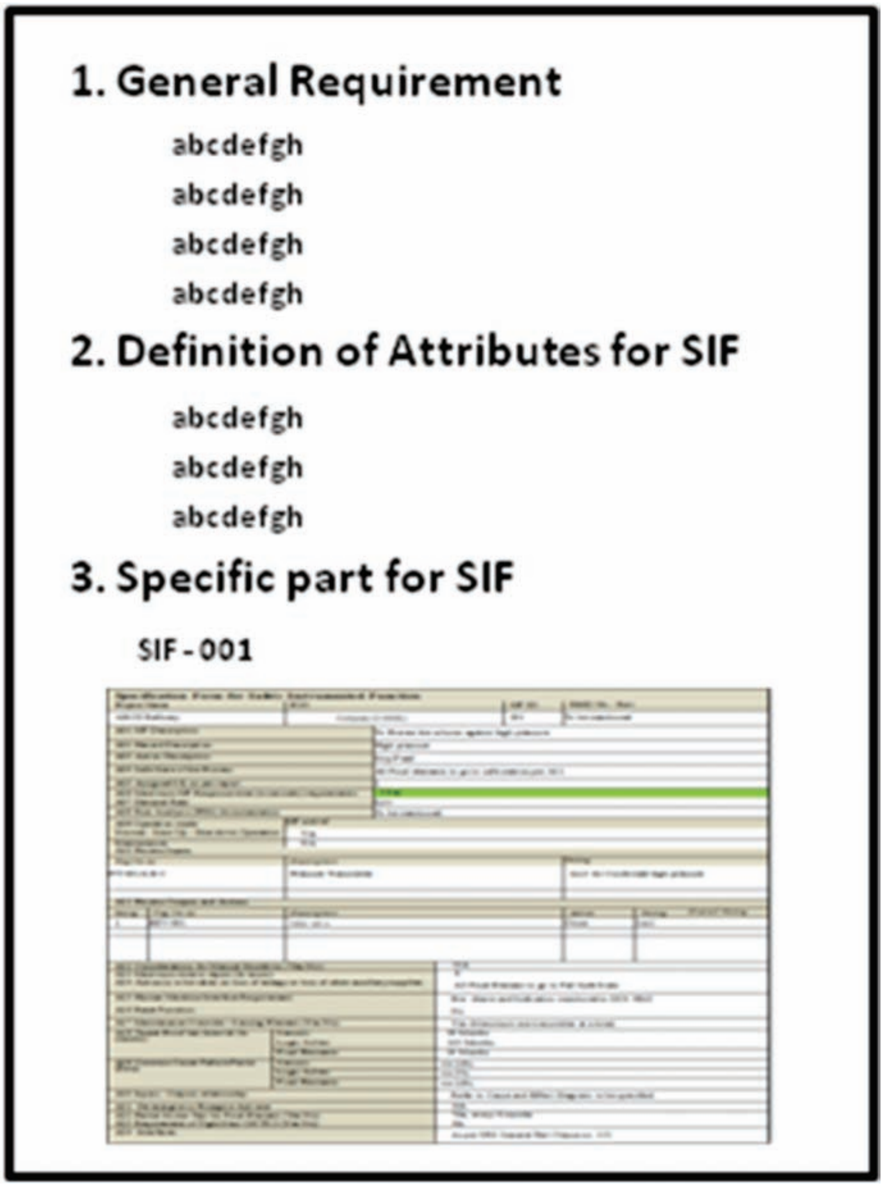
It should be preferred that the development of the SRS is carried out by competent personnel as defined by the standards. One of the ways to prove competence in the area of functional safety is certified personnel from certification agencies like TUV/Exida/ISA/Equivalent.

The SRS should be prepared per process unit so that only relevant information is provided to the users, thus avoiding any conflicts on ownership of the document. However, overall responsibility should be assigned to a competent person to ensure consistency between the process units within a facility.

What – What should be the content of the SRS:

This is the most important question which is necessary to be answered for development of a good SRS. As we know, the SRS should define the Functional and Integrity requirements of the Safety Instrumented Function to be implemented in Safety Instrumented System. The SRS represents the collection of the documents which defines these requirements.

The SRS therefore can be classified in two groups. The first of this group is the 'SRS base document' which would detail out the requirements related to SIF, its SIL and configuration parameters associated with reliability, SIL verification, validation and proof testing. The second of this group is documents related to the configuration of the SIF with relation to the process safety. These are documents such as Cause and Effect, Logic narratives, Alarm and Trip schedules. This paper refers to the documents under the second group as associated SRS documents.


1. General Requirement

abcdefgh

abcdefgh

abcdefgh

abcdefgh

2. Definition of Attributes for SIF

abcdefgh

abcdefgh

abcdefgh

3. Specific part for SIF

SIF - 001

Figure- 3: Typical Format for SRS Base document

This paper covers the requirements of the SRS base document which is often titled as ‘Safety Requirements Specification’.

The SRS base document is divided in to three parts, i) general requirement, ii) Definition of attributes of the SIF to define functional and integrity requirements and iii) Specific part defining each SIF and its attributes configuration. The Figure- 3 provides the format for the SRS base document. The requirements of each of the part are described in the following section.

General Requirement

The general requirement of SRS should cover the below aspects:

- Reference standards against which the SIS should be designed (e.g. IEC 61508, IEC 61511 etc)

- Reference of the SIS design documents (e.g. P&IDs, C&E, SIL assignment report, SIS specifications etc)
- Competence requirements related to SIS life cycle activities
- Criteria for selection of sensing elements, logic solver and final elements
- Interface and interactions with other systems and supervisory systems
- Testing and verification requirements

Definition of Attributes of SIF

Section 10.3, Part 1 of the IEC 61511 defines the attributes which are sufficient for the design of the SIS. These are listed and expected definitions are explained in brief below.

- A description of all the safety instrumented functions necessary to achieve the required functional safety. This would be included for each SIF in the specific part.
- Requirements to identify and take account of common cause failures. Possible common cause failures (CCF) must be taken into account while designing of the SIS. Resulting factors shall be considered for the calculation of probability of failure on demand. The CCF is represented in terms of β and applicable for voted devices or same make and model devices which are part of the SIF (voted transmitters, redundant processor/power supply modules). The β value which would be used should be generalized. In case of any variation, it can be highlighted in the specific part.
- A definition of the safe state of the process for each identified safety instrumented function. Generally this should indicate the action on the final element which need to be performed and achieved (e.g. close command to a valve and confirmation of valve close).
- A definition of any individually safe process states which, when occurring concurrently, create a separate hazard (for example, overload of emergency storage, multiple relief to flare system). This input should be provided by the process / operations discipline.
- The assumed sources of demand and demand rate on the safety instrumented function. This basis is typically developed during the HAZOP and SIL assignment studies. The assumed source of demand can be for e.g. 'heard in industry' or 'occurred in organization' and demand rate can be expressed for example the hazardous event occurring once in 10 years.
- Requirement for proof-test intervals. The SIF loop periodic proof testing shall be carried out on a fixed schedule as determined in the specific part (proof test interval) to detect if there is any dormant failure in the SIF. These tests shall be conducted by fully trained and competent persons, with all such tests or maintenance activities being fully documented, signed and approved by authorized persons. Voted devices should not be tested together. The diagnostic coverage of each test expected should be documented.
- Response time requirements for the SIS to bring the process to a safe state. The response time of the SIF (sensing element + logic solver + final element) should not exceed the process safety time.
- The safety integrity level and mode of operation (demand/ continuous) for each

safety instrumented function. The SIL of each SIF is mentioned in the specific part. The mode of operation for process industry normally is considered to be low demand mode.

- A description of SIS process measurements and their trip points. This information is covered in the document such a C&E, Alarm and trip schedule. However, if any alarm is considered as an independent protection layer for a SIF, that should be mentioned in the specific part.

- A description of SIS process output actions and the criteria for successful operation, for example, requirements for tight shut-off valves. The criterion for successful operation is to decide which final Elements are to be activated when the certain set point is reached. In addition, it also includes e.g. requirements for tight shut-off (TSO), Partial Stroke Test (PST), Fail Safe position, Opening/closing time, Voting Logic, etc.

- The functional relationship between process inputs and outputs, including logic, mathematical functions and any required permissive. This is often covered in the associated SRS documents and need not be repeated in the SRS base document.

- Requirements for manual shutdown. In addition to automated shutdown from SIS, the SIF can be configured to achieve safe state on activation of push button located strategically (e.g. CCR, field etc). This should be clearly identified in the specific part of the SRS.

- Requirements relating to energize or de-energize to trip. Normally, the ESD applications are configured with de-energize to trip applications. Any energize to trip design should be reviewed and specific requirements to achieve that should be captured in the specific part so that the same can be verified. Applications such as F&G may have functions which require energize to actuate and should additionally follow the requirements of NFPA.

- Requirements for resetting the SIS after a shutdown. Unless specified, each SIF shall be designed such that once it has been placed the process in a safe state; it shall remain in the safe state until a reset has been initiated. The location of reset depends on the operation and organization philosophy; however the HMI resets are generally preferred. The philosophy of reset should be detailed in this part of the SRS.

- Maximum allowable spurious trip rate. The chosen components should have low spurious trip rate. For critical services, redundant or voted devices can be selected to avoid uptime loss. For example, the logic solver components are generally specified as redundant as a spurious trip on logic solver would result in multiple SIFs going into shutdown.

- Failure modes and desired response of the SIS (for example, alarms, and automatic shutdown) should be clearly defined. This is critical requirement as operating the process with failures in the SIS components can be dangerous. Philosophy of operation on such failures should be defined in this part of SRS and depending upon the architecture of the SIF, any additional requirements can be defined in the specific part of the SIF.

- Any specific requirements related to the procedures for starting up and restarting the SIS. This should be similar to the reset of the SIF. Any specific requirements to a SIF should be covered in the specific part.

- All interfaces between the SIS and any other system (including the BPCS and operators) should be defined. Initiation of trip from the HMI should be avoided. Any trip signals from package systems or condition monitoring systems should be hardwired.

- A description of the modes of operation of the plant and identification of the safety instrumented functions required to operate within each mode. The SIF's may have additional or reduced requirements during the start-up and normal operations. These conditions need to be identified in the specific part of SIF.

- The application software safety requirements should be established to ascertain the requirements of use of utility software for development of application software. Reviews and test should be planned for the application software to ensure the required functionality is met. The criterion for security, back-up etc also need to be identified.

- Requirements for overrides / inhibits / bypasses including how they will be cleared. These requirements should be carefully analyzed and defined. Any start-up overrides should be avoided or should be applied for limited time frame. Overrides or bypass should be applied only on input devices when alternative protection arrangement exists. Outputs should not be overridden or bypassed.

- The specification of any action necessary to achieve or maintain a safe state in the event of fault(s) being detected in the SIS. Any such action shall be determined taking account of all relevant human factors.

- The mean time to repair which is feasible for the SIS should be defined. This should be defined taking into consideration the time to travel to location, troubleshoot and diagnose, spares holding, service contracts, environmental constraints etc.

- Identification of the dangerous combinations of output states of the SIS that need to be avoided should be identified in the HAZOP and also should be mentioned in the specific part of the SIF. Any restrictions on proof testing due to this should also be clearly identified.

- The extremes of all environmental conditions that are likely to be encountered by the SIS shall be identified. It needs to be ensured that the selected components of the SIF meet these conditions. If not, then there might be early wear out or failures of the SIF component or it may even result in to undefined behavior of the component.

- Identification to normal and abnormal modes for both the plant as a whole (for example, plant start-up) and individual plant operational procedures (for example, equipment maintenance, sensor calibration and/or repair). Additional safety instrumented functions may be required to support these modes of operation. These restrictions should be clearly identified in the specific part of the SRS.

- Definition of the requirements for any SIF necessary to survive a major accident event should be identified. For example, time required for a valve to remain operational in the event of a fire, loss of instrument air need or the specification of cables and junction box to resist fires should be identified.

Specific part providing configuration parameters of each SIF

The development of SRS base document with specific part should be the 2st step. The complete list of all the SIFs with SIF description and SIL level should be summarized in a table continued by filling of SIF datasheet for each listed SIF. The sample format for this is provided in the Figure- 4 below.

When – When should be the SRS developed

The initial revision of the SRS can be started only after the allocation of the SIFs to the protection layers is completed. The data for the number of the SIFs, its SIL, independent protection layers and criteria for particular SIL for a SIF is available.

The SRS development undergoes iterations during the design phase. As the engineering progresses, the SRS gets appended with more and more information to ensure complete definition of each SIF.

The SRS should be updated post completion of the SIL verification based on the necessary fine tunings on the proof testing frequencies.

The development of SRS base document with generic requirements should be the 1st step. The development of the associated SRS documents should happen in parallel with this. The SRS base document in the 2nd step should be completed for all the SIFs with the SIF specific information.

How – How to ensure the correctness of the SRS:

To ensure that the SRS is applied correctly, some attributes of SRS are detailed below:

- The SRS should be clear, precise, unambiguous, maintainable and feasible. This means that the stated requirements should not leave it for the user to assume any of the requirements which might lead to inconsistency, inaccurate design and improper maintenance of the SIS.
- The SRS should be verifiable and testable. This means the requirements should be clearly stated rather than open ended statements. For example, statement like 'the scan time for the SIS should be fast to mitigate the hazard' would not be verifiable as how fast is good enough. Rather, if it's clearly specified that 'the scan time for the logic solver should be less than 300 msec', it can be verified and tested during the logic solver tests.
- The SRS should aid comprehension for the user at any lifecycle stage of the SIS. The users of SRS generally have enough resources to know and understand its content during design phase. However, the SRS should contain sufficient details for the users who might use the SRS during verification, validation or proof testing activities in the safety lifecycle.
- If necessary, to reduce complexity, a hierarchical structure of partial requirements can be established.
- Use of checklist shall be limited as it depends upon the competence of the engineer selecting and applying checklist.
- The SRS should be reviewed and assessed by independent team to check for the completeness and verify that there are no contradictory requirements stated. Independent reviews should also focus on reviewing whether the SRS doesn't over specify (can result in higher implementation and maintenance costs) or under specify (can result in not meeting the required risk reduction) the requirements.

CONCLUSION

SRS is a key document and adequate focus should be provided in its development similar to HAZOP

<table>
<tr><th colspan="7">Specification Form for Safety Instrumented Function</th></tr>
<tr><td colspan="2">Project Name</td><td colspan="2">EUC</td><td>SIF ID</td><td colspan="2">P&ID No. / Rev.</td></tr>
<tr><td colspan="2">ABCD Refinery</td><td colspan="2">Column (C-0001)</td><td>001</td><td colspan="2">To be mentioned</td></tr>
<tr><td colspan="3">A01 SIF Description:</td><td colspan="4">To Protect the column against high pressure</td></tr>
<tr><td colspan="3">A02 Hazard Description:</td><td colspan="4">High pressure</td></tr>
<tr><td colspan="3">A03 Action Description:</td><td colspan="4">Stop Feed</td></tr>
<tr><td colspan="3">A04 Safe State of the Process:</td><td colspan="4">All Final elements to go to safe state as per A11.</td></tr>
<tr><td colspan="3">A05 Assigned SIL as per report</td><td colspan="4">2</td></tr>
<tr><td colspan="3">A06 Maximum SIF Response time (in seconds) requirements</td><td colspan="4">: 3 Sec</td></tr>
<tr><td colspan="3">A07 Demand Rate</td><td colspan="4">Low</td></tr>
<tr><td colspan="3">A08 Risk Analysis (PHA) documentation</td><td colspan="4">To be mentioned</td></tr>
<tr><td colspan="2">A09 Operation mode</td><td colspan="5">SIF active?</td></tr>
<tr><td colspan="2">Normal / Start-Up / Shut down Operation</td><td colspan="5">Yes</td></tr>
<tr><td colspan="2">Maintenance</td><td colspan="5">NA</td></tr>
<tr><td colspan="7">A10 Process Inputs</td></tr>
<tr><td colspan="2">Tag No.(s)</td><td colspan="3">Description</td><td colspan="2">Voting</td></tr>
<tr><td colspan="2">PT-001A/B/C</td><td colspan="3">Pressure Transmitter</td><td colspan="2">2oo3 for Confirmed high pressure</td></tr>
<tr><td colspan="2"></td><td colspan="3"></td><td colspan="2"></td></tr>
<tr><td colspan="2"></td><td colspan="3"></td><td colspan="2"></td></tr>
<tr><td colspan="7">A11 Process Outputs and Actions</td></tr>
<tr><td>Group</td><td>Tag No.(s)</td><td colspan="2">Description</td><td>Action</td><td>Voting</td><td>Overall Voting</td></tr>
<tr><td>1</td><td>PZV-001</td><td colspan="2">Inlet valve</td><td>Close</td><td>1oo1</td><td></td></tr>
<tr><td></td><td></td><td colspan="2"></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td colspan="2"></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td colspan="2"></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td colspan="2"></td><td></td><td></td><td></td></tr>
<tr><td colspan="3">A12 Considerations for Manual Shutdown (Yes/No):</td><td colspan="4">NA</td></tr>
<tr><td colspan="3">A13 Maximum time to repair (In hours):</td><td colspan="4">8</td></tr>
<tr><td colspan="3">A14 Action(s) to be taken on loss of energy or loss of other auxiliary supplies:</td><td colspan="4">All Final Element to go to Fail Safe State.</td></tr>
<tr><td colspan="3">A15 Human Machine Interface Requirement:</td><td colspan="4">Pre- Alarm and Indication monitored in DCS HMI</td></tr>
<tr><td colspan="3">A16 Reset Function:</td><td colspan="4">No</td></tr>
<tr><td colspan="3">A17 Maintenance Override – Sensing Element (Yes/No):</td><td colspan="4">Yes (Maximum one transmitter at a time)</td></tr>
<tr><td colspan="2" rowspan="3">A18 Target Proof test Interval (In months)</td><td>Sensors:</td><td colspan="4">36 Months</td></tr>
<tr><td>Logic Solver:</td><td colspan="4">120 Months</td></tr>
<tr><td>Final Elements:</td><td colspan="4">24 Months</td></tr>
<tr><td colspan="2" rowspan="3">A19 Common Cause Failure Factor (Beta)</td><td>Sensors:</td><td colspan="4"><= 10%</td></tr>
<tr><td>Logic Solver:</td><td colspan="4"><= 5%</td></tr>
<tr><td>Final Elements:</td><td colspan="4"><= 10%</td></tr>
<tr><td colspan="3">A20 Inputs / Outputs relationship:</td><td colspan="4">Refer to Cause and Effect Diagram: to be specified</td></tr>
<tr><td colspan="3">A21 De-energize or Energize Activate:</td><td colspan="4">NA</td></tr>
<tr><td colspan="3">A22 Partial Stroke Test for Final Element (Yes/No):</td><td colspan="4">Yes, every 6 months</td></tr>
<tr><td colspan="3">A23 Requirement of Tight Shut-Off TSO (Yes/No):</td><td colspan="4">No</td></tr>
<tr><td colspan="3">A24 Interfaces:</td><td colspan="4">As per SRS General Part Clause no. 123.</td></tr>
</table>

Figure- 4: SIF Template – Specific Part of SRS and SIL assignment. A good SRS provides solid basis for the design of the SIS and further ensures that the criteria for the other lifecycle activities such as verification, validation and proof testing is established. It should be understood that the SRS is a live document and owners identified for its development and maintenance in each phase of the safety lifecycle. Further, it requires multi-disciplinary inputs and all stake holders should be made aware of the responsibilities to provide inputs at appropriate time.

A good SRS document would enable reduce the 44% of specification errors.

ACRONYMS

IPL	Independent Protection Layer
SIS	Safety Instrumented System
SIF	Safety Instrumented Function
SIL	Safety Integrity Level
SRS	Safety Requirements Specification

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[2] IEC, IEC 61511, Functional Safety of Instrumented Systems for the Process Industry Sector.

[3] Out of Control – Why Control Systems Go Wrong and How to Prevent Failures.

ACKNOWLEDGEMENTS

I would like to thank P.K. Midha, Control System head of department, Fluor Daniel India Pvt. Ltd. for his continuous support and motivation in completion of this paper.

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BIOGRAPHY

Amit is an Instrumentation engineer with 19+ years of professional experience in process industry. He is working with Fluor Daniel India pvt. Ltd. for almost three years and previously worked with Honeywell India for around fourteen years. He has extensively worked on Safety System projects in different roles which involved activities like design and detailed engineering, HAZOP, SIL assignment and verification, Front End Engineering and Design (FEED), commissioning, project cost estimation and consultancy. Apart from India, he has worked on various projects across globe at locations like South Korea, Norway, UK, UAE, Netherlands, USA, Philippines and Australia.

He is a TUV Rheinland certified Functional Safety Expert (TUV Rheinland FS Expert ID: 189/12)

Industrial Internet:
Industrial Analytics to drive profitable outcomes

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ABSTRACT:

Software has begun to influence our society directly. Digital consumer companies are disrupting the old guard and changing the way we live and do business in fundamental ways. Companies such as Uber, Airbnb and Zipcar have disrupted the traditional businesses of taxis, hotels and car rental companies by leveraging software capabilities to create new business models. Opportunities in the industrial world are expected to outpace consumer business cases substantially. Focusing on the power, oil and gas space, there are significant opportunities to derive value. General Electric (GE) is focused on driving new value for industrial organizations by offering them advanced software capabilities that connect data, analytics and knowledge from machine, human (i.e., root cause learnings, knowledge management), and maintenance operations.

Companies within the industrial space are racing to achieve the next level of optimization for their equipment, people and maintenance activities. Bold action plans regarding digitization of platforms, power plant assets & processes, pipeline networks, and facilities that link to integrated operating centers are widely becoming normative. To truly be successful in this digitized world, it is imperative that the machine data, human knowledge, and maintenance strategies be linked to achieve these action plans.

This paper discusses about the need and creation of the integrated all-in-one view enterprise performance management and asset health management solutions providing a holistic and quantifiable view of operations, maintenance, availability and overall operating performance for production assets. This paper also discussed about how integrated solution leverages machine diagnostics and health data to drive proactive maintenance practices reducing overall maintenance costs and driving improved reliability at an asset level, greater productivity at a fleet level and ultimately, business profitability across the enterprise. GE believes that it is paramount to empower industries to choose what is wrapped and integrated into an enterprise solution. Legacy systems, and already established data warehouses can successfully be integrated into the GE APM solution.

KEY WORDS:

Industrial Internet, Asset performance Management, APM, PredixTM , Reliability

RISE OF THE INDUSTRIAL INTERNET:

Over the last 200 years, the world has experienced several waves of innovation. Successful companies learned to navigate these waves and adapt to the changing environment. Today we are at the cusp of another wave of innovation that promises to change the way we do business and interact with the world of industrial machines. This is the "Industrial Internet."

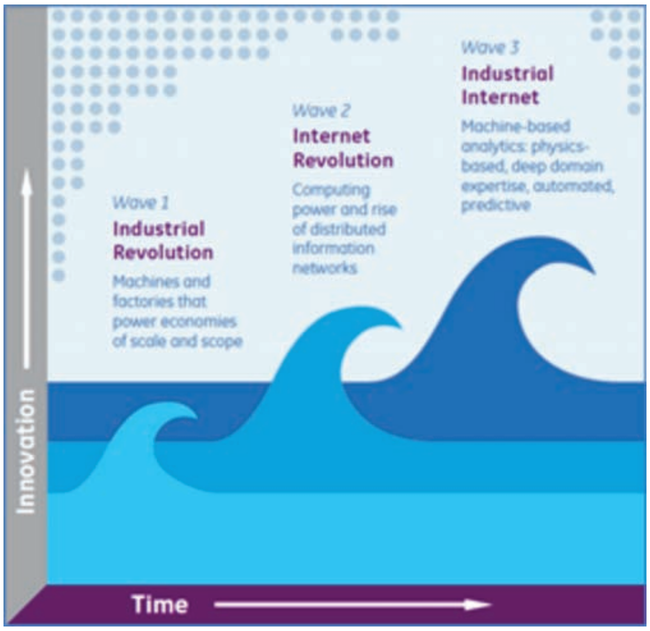


Fig – 1: Rise of Industrial Internet

Several key features characterized this period. It was marked by the rise of the large industrial enterprise spanning new industries from textiles to steel to power production. It created significant economies of scale and corresponding reduction in costs as machines and fleets got larger and production volumes increased. It harnessed the efficiencies of hierarchical structures, with centralization of control. The global capital stock of dedicated plant and equipment grew dramatically. Innovation began to be thought of in a systematic way, with the rise of central laboratories and centers for research and development (R&D). Enterprises, both large and small, worked to harness new inventions in order to create and profit from new markets. Despite the enormous gains reaped by the economy and society, the Industrial Revolution also had a downside. The global economic system became more highly resource-intensive and had a more significant impact on the external environment as a result of both resource extraction and industrial waste streams. In addition, working conditions during this era needed vast improvement. Much of the incremental innovation that has occurred since the Industrial Revolution has been focused on improving efficiency, reducing waste and enhancing the working environment.

The Second Wave: The Internet Revolution:

At the end of the twentieth century, the Internet Revolution changed the world yet again. The timeframe in which it unfolded was much shorter, taking place over about 50 years instead of 150. It changed thinking about production systems by permitting deeper integration and more flexible operations. Also, rather than an ordered linear approach to research and development, the Internet has enabled concurrent innovation. The ability to exchange information rapidly and decentralize decision-making has spawned more collaborative work environments that are unconstrained by geography. As a Consequence, older models of centralized internal innovation have ceded ground to start-ups and more open innovation models that harness an environment of more abundant knowledge. Thus, rather than resource- intensive, the Internet Revolution has been information and knowledge intensive. It has highlighted the value of networks and the creation of platforms. It has opened up new avenues to reduce environmental footprints and support more eco-friendly products and services.

The Third Wave: The Industrial Internet:

Today, in the twenty-first century, the Industrial Internet promises to transform our world yet again. The melding of the global industrial system that was made possible as a result of the Industrial Revolution, with the open computing and communication systems developed as part of the Internet Revolution, opens up new frontiers to accelerate productivity, reduce inefficiency and waste, and enhance the human work experience. Indeed, the Industrial Internet Revolution is already underway. Companies have been applying Internet-based technologies to industrial applications as they have become available over the last decade. However, we currently stand far below the possibility frontier: the full potential of Internet-based digital technology has yet to be fully realized across the global industry system. Intelligent devices, intelligent systems, and intelligent Decisioning represent the primary ways in which the physical world of machines, facilities, fleets and networks can more deeply merge with the connectivity, big data and analytics of the digital world.

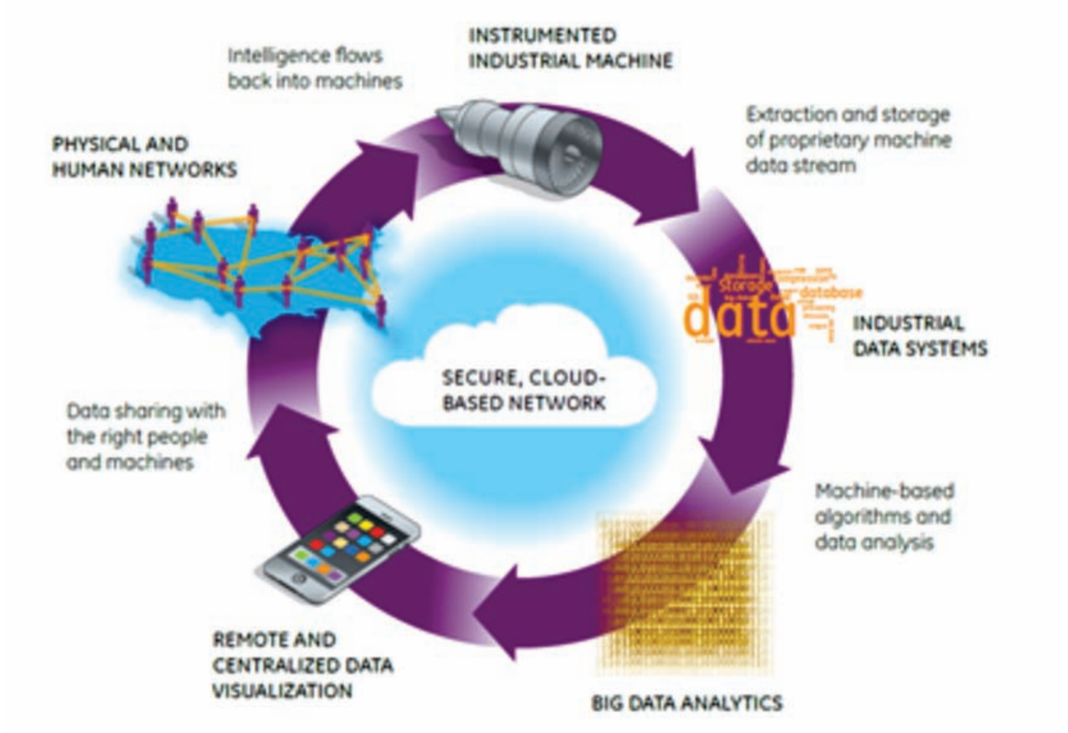


Fig – 2: Industrial Internet Data Loop

The resultant "intelligent information" can then be acted upon by decision makers, in real-time if necessary, or as part of broader industrial assets optimization or strategic decision processes across widely diverse industrial systems.

Intelligent information can also be shared across machines, networks, individuals or groups to facilitate intelligent collaboration and better decision making. This enables a broader group of stakeholders to engage in asset maintenance, management and optimization. It also ensures that local and remote individuals that have machine specific expertise are brought into the fold at the right time. Intelligent information can also be fed back to the originating machine. This not only includes data that was produced by the originating machine, but also external data that can enhance the operation or maintenance of machines, fleets and larger systems. This data feedback loop enables the machine to "learn" from its history and behave more intelligently through on-board control systems. Each instrumented device will produce large quantities of data that can be transferred via the Industrial Internet network to remote machines and users. In this manner, operating data and predictive analytics can be combined to avoid unplanned outages and minimize maintenance costs. All of these benefits come from machine instrumentation using existing information technologies and doing so in ways that enable people to do their jobs more effectively.

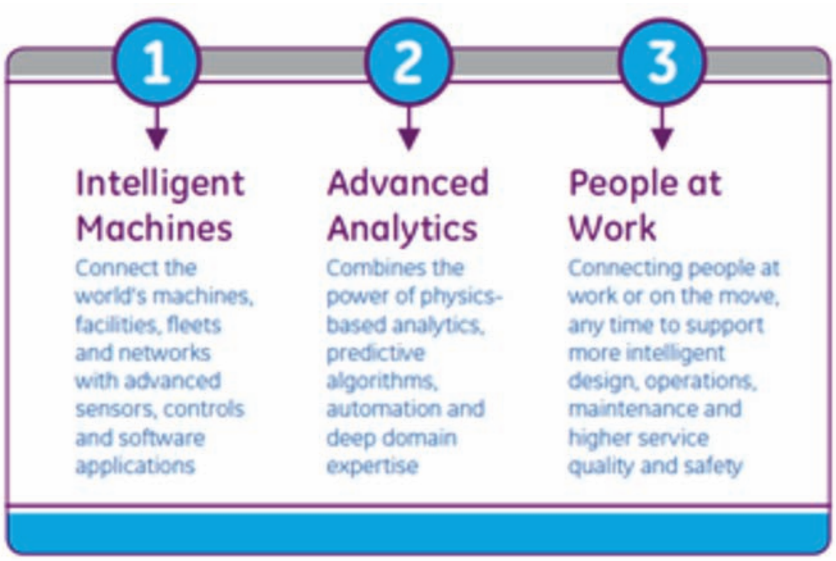


Fig. – 3: Key Elements of the Industrial Internet

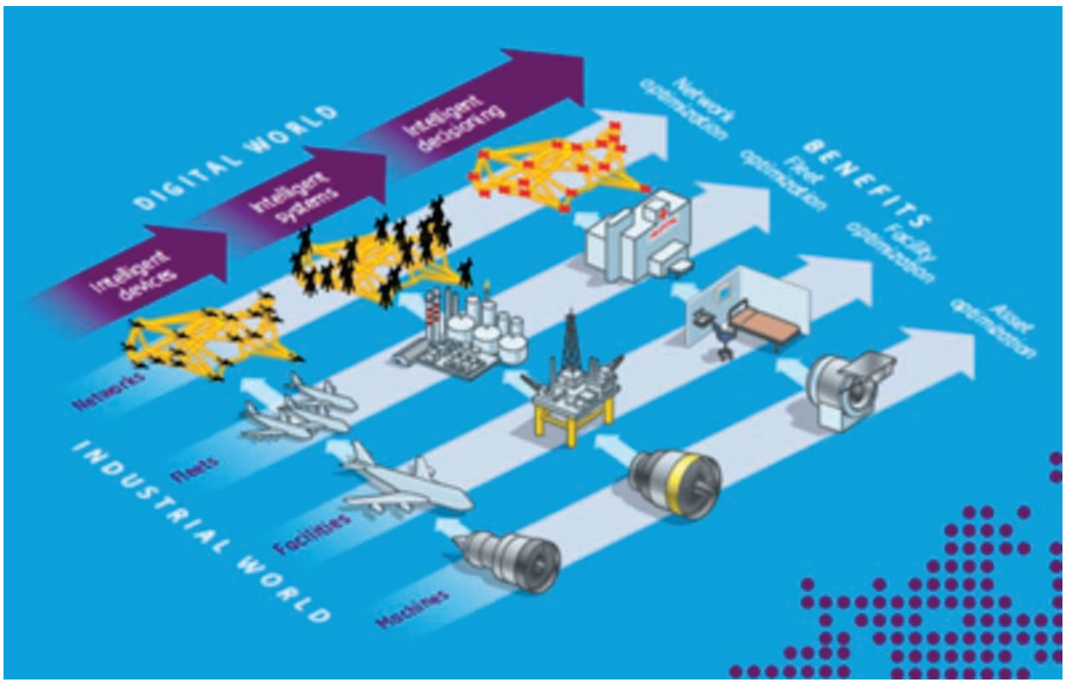


Fig – 4: Application of Industrial Internet

Network Optimization: The operation of interconnected machines within a system can be coordinated to achieve operational efficiencies at the network level.

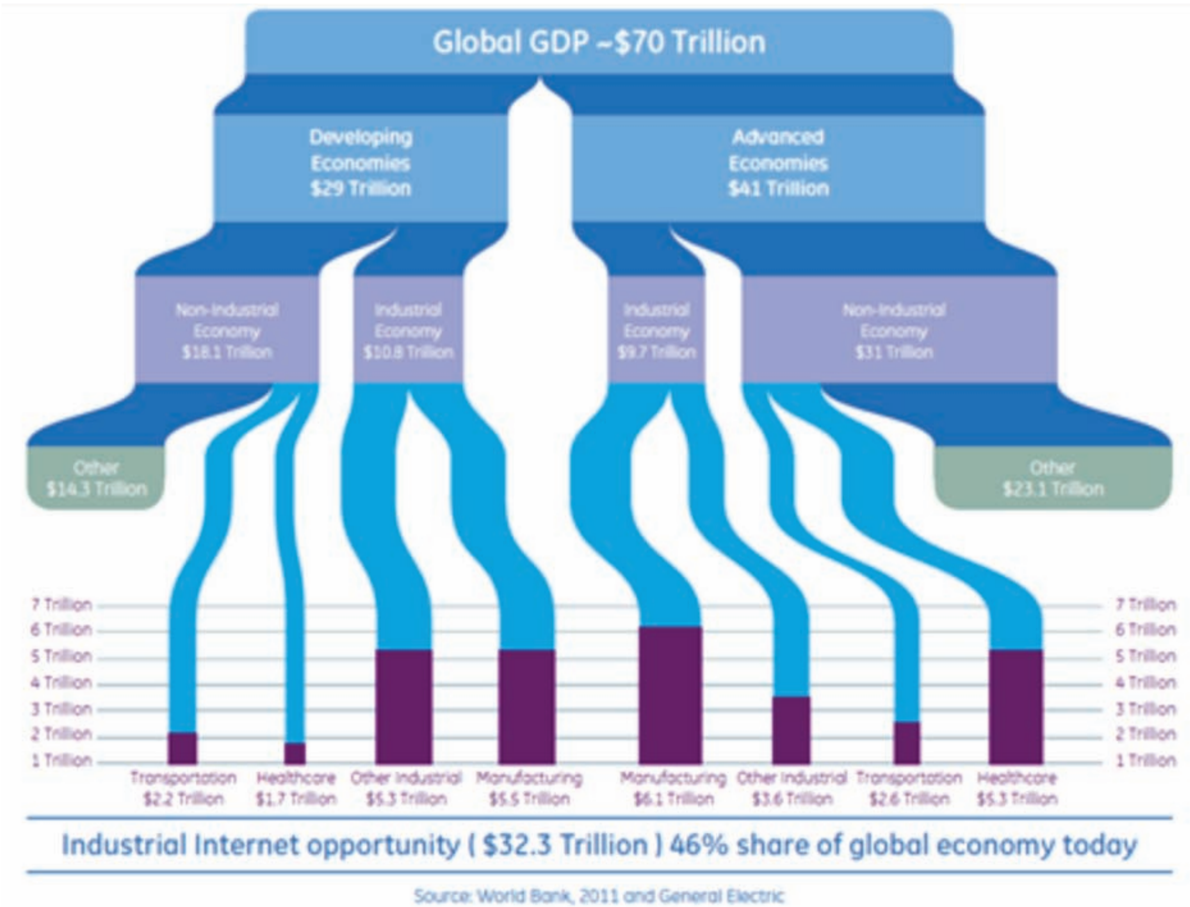
Intelligent system maintenance optimization can be combined with network learning and predictive analytics to allow engineers to implement preventive maintenance programs that have the potential to lift machine reliability rates to unprecedented levels. System Recovery: Establishing broad system-wide intelligence can also assist in more rapidly and efficiently restoring systems after major shocks. Learning: Network learning effects are another benefit of machine interconnection with a system. The operational experiences of each machine can be aggregated into a single information system that accelerates learning across the machine portfolio in a way that is not possible with a single machine. The insights derived from this data are actionable and can be used to make the entire system smarter, thereby driving a continuous process of knowledge accumulation and insight implementation. Building out intelligent systems harnesses the benefits of widely deploying intelligent devices. Once an increasing number of machines are connected within a system, the result is a continuously expanding, self-learning system that grows smarter over time.

Intelligent DECISIONING: The full power of the Industrial Internet will be realized with a third element—Intelligent Decisioning. Intelligent Decisioning occurs when enough information has been gathered from intelligent devices and systems to facilitate data-driven learning, which in turn enables a subset of machine and network-level operational functions to be transferred from operators to secure digital systems. This element of the Industrial Internet is essential to grapple with the increasing complexity of interconnected machines, facilities, fleets and networks. The challenges of this complexity can be overcome by enabling the system to perform select operations with human consent. The burden of complexity is transferred to the digital system. Intelligent Decisioning is the long-term vision of the Industrial Internet. It is the culmination of the knowledge gathered as the elements of the Industrial Internet are assembled device-by-device and system-by- system. It is a bold vision that, if realized, can unlock productivity gains and reduce operating costs on a scale comparable to the Industrial and Internet Revolutions. Using a combination of physics based methodologies, deep sector-specific domain expertise, increased automation of information flows, and predictive techniques, advanced analytics can be joined with the existing suite of "big data" tools. The result is the Industrial Internet encompasses traditional approaches with newer hybrid approaches that can leverage the power of both historic and real-time data with industry-specific advanced analytics.

The Benefits of the Industrial Internet:

The Industrial Internet promises to have a range of benefits spanning machines, facilities, fleets and industrial networks, which in turn influence the broader economy. Some companies have been early adopters, realizing benefits and overcoming challenges related to capturing and manipulating data streams. Given the size of the asset base involved, broader integration of systems and sub-systems at the product level through intelligent devices is expected as sensing and data handling costs fall. At the other end of the spectrum, enterprise management software and solutions have been widely adopted to drive organizational efficiencies at the firm level. The benefits of these efforts include better tracking and coordination of labor, supply chain, quality, compliance, and sales and distribution across broad geographies and product lines. However, these efforts have sometimes fallen short because while they can passively track asset operations at the product level, the ability to impact asset performance is limited. Optimizing the system to maximize asset and enterprise performance is what the Industrial Internet offers.

The Industrial Internet opens the door to a variety of benefits for the industrial economy.



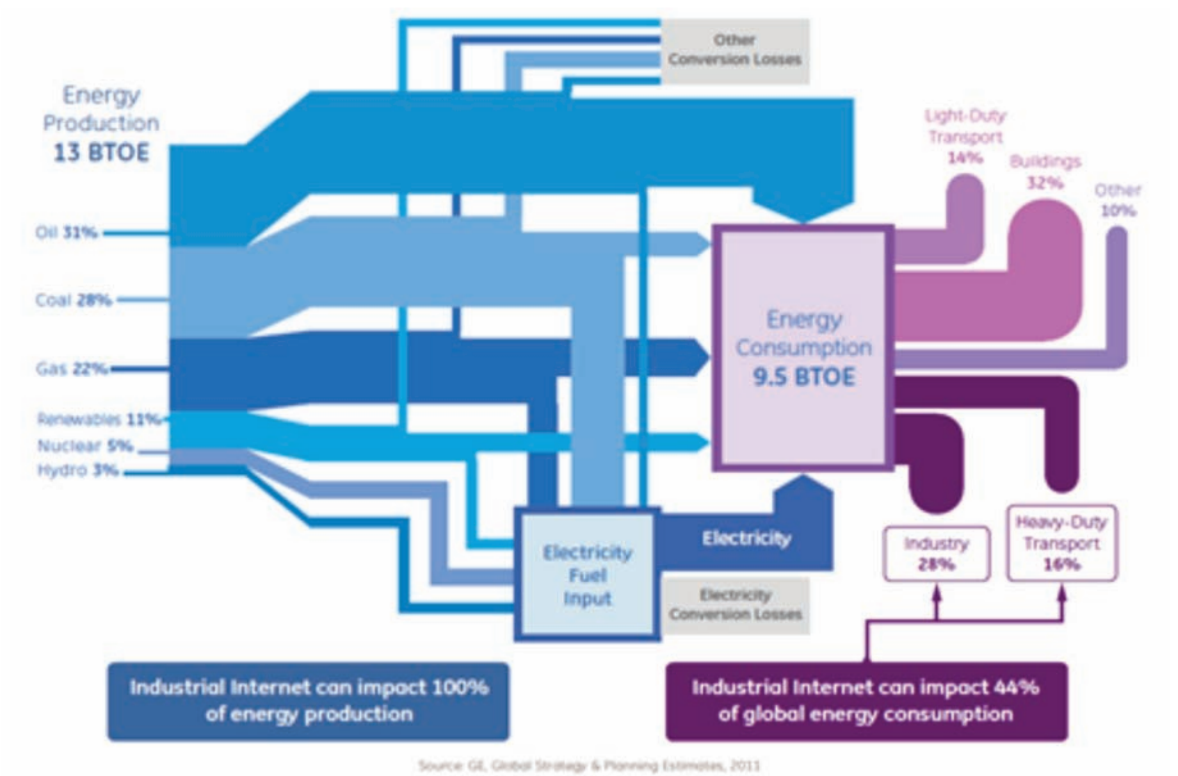


Fig. - 6: 2011 Global Energy Flows

Table 2. Things that Spin: Illustrative List of Rotating Machines

Sector		# of Global Assets & Plants	"Big" things that spin
Transportation	**Rotating Machinery**		
Rail: Diesel Electric Engines	Wheel Motors, Engine, Drives, Alternators	120,000	2,160,000
Aircraft: Commercial Engines	Compressors, Turbines, Turbofans	43,000	129,000
Marine: Bulk Carriers	Steam Turbines, Reciprocating Engines, Pumps, Generators	9,400	84,600
Oil and Gas	**Rotating Machinery**		
Big Energy Processing Plants (1)	Compressors, Turbines, Pumps, Generators, Fans, Blowers, Motors	990	36,900
Midstream Systems (2)	Engines, Turbines, Compressors, Turbo Expanders, Pumps, Blowers	16,300	63,000
Drilling Equipment: Drillships, Land Rigs etc.	Engines, Generators, Electric Motors, Drilling Works, Propulsion Drives	4,100	29,200
Power Plants	**Rotating Machinery**		
Thermal Turbines: Steam, CCGT, etc.	Turbines, Generators	17,500	74,000
Other Plants: Hydro, Wind, Engines, etc. (3)	Turbines, Generators, Reciprocating Engines	45,000	190,000
Industrial Facilities	**Rotating Machinery**		
Steel Mills	Blast and Basic Oxygen Furnace Systems, Steam Turbines, Handling Systems	1,600	47,000
Pulp and Paper Mills	Debarkers, Radial Chippers, Steam Turbines, Fourdrinier Machines, Rollers	3,900	176,000
Cement Plants	Rotary Kilns, Conveyors, Drive Motors, Ball Mills	2,000	30,000
Sugar Plants	Cane Handling Systems, Rotary Vacuums, Centrifuges, Cystalizers, Evaporators	650	23,000
Ethanol Plants	Grain Handling Systems, Conveyors, Evaporators, Reboilers, Dryer Fans, Motors	450	16,000
Ammonia and Methanol Plants	Steam Turbines, Reformer and Distillation Systems, Compressors, Blowers	1,300	45,000
Medical Machines	**Rotating Machinery**		
CT Scanners	Spinning X-Ray Tube Rotors, Spinning Gantries	52,000	104,000
		Total	**3,207,700**

Notes: Not exhaustive. (1) includes LNG processing trains, Refineries, and Ethylene steam crackers. (2) includes Compressor and pumping stations, LNG regasification terminals, Large Crude carriers, gas processing plants. (3) Only counting engines in large scale power generation greater than 30 MW

Sources: Multiple aggregated sources including Platts UDI, IHS-CERA, Oil and Gas Journal, Clarkson Research, GE Aviation & Transportation, InMedica, industrial info, RISI, US Dept. of Energy, GE Strategy and Analytics estimates of large rotating systems

Table 1: Things that Spin: Illustrative List of Rotating Machines

What if... Potential Performance Gains in Key Sectors

Industry	Segment	Type of Savings	Estimated Value Over 15 Years (Billion nominal US dollars)
Aviation	Commercial	1% Fuel Savings	$30B
Power	Gas-fired Generation	1% Fuel Savings	$66B
Healthcare	System-wide	1% Reduction in System Inefficiency	$63B
Rail	Freight	1% Reduction in System Inefficiency	$27B
Oil & Gas	Exploration & Development	1% Reduction in Capital Expenditures	$90B

Note: Illustrative examples based on potential one percent savings applied across specific global industry sectors.
Source: GE estimates

Table 2: Industrial Internet: The Power of 1 Percent

Productivity is the ultimate engine of economic growth, a key driver of higher incomes and better living standards. Faster growth in labor productivity allows a workforce to produce more and to earn increased wages. And in an era where constraints are powerful and pervasive, productivity is even more important: higher productivity delivers greater benefits to firms and governments that need to make every dollar of investment count; and higher productivity makes every gallon or ton of natural resources go a longer way, a crucial contribution to sustainability as large emerging markets populations strive to achieve better living standards and greater consumption levels. The Industrial Internet can therefore be the catalyst for a new wave of productivity, with powerful beneficial consequences in terms of economic growth and incomes.

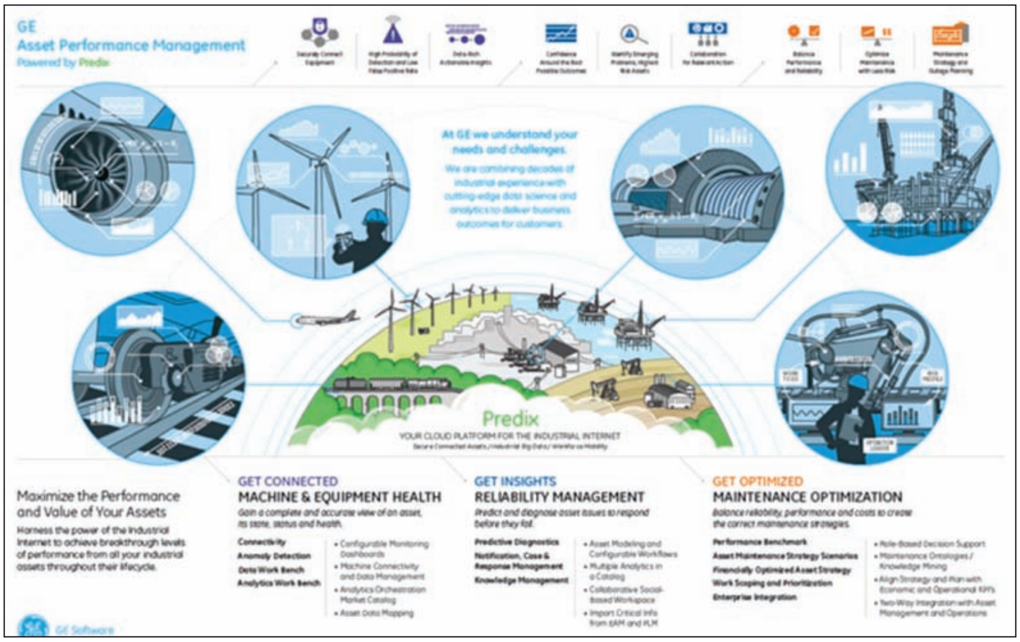


Fig. - 7: Get Connected, Get Insights, Get Optimized

The speed at which the benefits of the Industrial Internet can feed through the global economy will also depend on firms' ability to incorporate them in their business processes; and this in turn will also depend on the business environment and the economic policies that help shape it. The benefits of the Industrial Internet derive not just from the greater efficiency of capital equipment, from the ability to push machines and devices to their technical limits. They derive also from the ability to optimize operations, and to optimize the speed of improvement of operations. This requires changes in business practices to go hand in hand with the technical innovation.

Realizing the potential of industrial internet:

The Industrial Internet is changing the way we manage and maximize global economic output. Combining brilliant machines with big data analytics enables valuable asset and operational insights in ways never before possible. Just as the consumer Internet has transformed people's ability to provide and access information anytime or anywhere, the Industrial Internet holds the potential to bring about profound transformation to industrial productivity and growth. The results are better performing and longer-lived physical machines, substantial savings in fuel and energy, and improved healthcare industry outcomes at a lower cost. The ability to capture this potential largely depends on the foundation upon which the solution ecosystem can be fostered. A software platform that can connect machines, data, and workers by supporting a variety of industrial data, new analytic capabilities, and

Innovative ways to collaborate will be key to transform this vision into a reality.

Fig. - 8: Software platform for the Industrial Internet

GET CONNECTED: Enable smarter operators with operational visibility anytime, anywhere. Connect your equipment and gain insights into your remote operations. Translate millions of data inputs to analyze asset performance across the enterprise. By connecting your systems and islands of data, you can get actionable information to solve your challenges faster. One can harness the power of the Industrial Internet, and asset performance management software to gain visibility into your operations, no matter how complex or remote.

GET INSIGHTS: Pre-empt issues with predictive maintenance and operations intelligence, reducing cost and extending asset life. Data analytics from operations allows you to identify and predict impending issues before they become real problems. In remote areas or harsh environments, you can monitor and diagnose issues and ensure equipment reliability and worker safety. Whether you are offshore on an oil rig or onshore in an oil field, analytics helps to connect you with the right information to pre-empt issues. One can anticipate maintenance requirements and problems.

GET OPTIMIZED: Optimize production and avoid unplanned downtime with analytic insights. Connect people, technology, and processes across your enterprise to drive operational optimization. By scaling big data and analytics across the enterprise, the best practices of one location can be applied across the total operation. Knowledge management can provide every person with the right information, no matter where they are in the organization, so issues can be resolved quickly and decisions can be made proactively. One can maximize operational efficiencies and minimize unplanned downtime.

ASSET PERFORMANCE MANAGEMENT:

Oil and gas industry operations are growing in complexity, as is the demand for operational efficiency. And as technology advances, so does the volume of data— and the need to harness it for useful insights that drive action. To address these issues, there is a need for a holistic Asset Performance Management (APM) software solution. With enterprise-wide visibility and knowledge management, it should allow industries to diagnose and solve problems faster, improve asset performance and availability, and maximize profitability. Such software solution should be capable of,

- Data Integration of machine & operational data and OEM agnostic.
- Asset Performance Visibility Dashboards, KPIs & analytics Views from fleet to equipment level.
- Collaboration Enablement Case management Knowledge management Simplified expert networking.

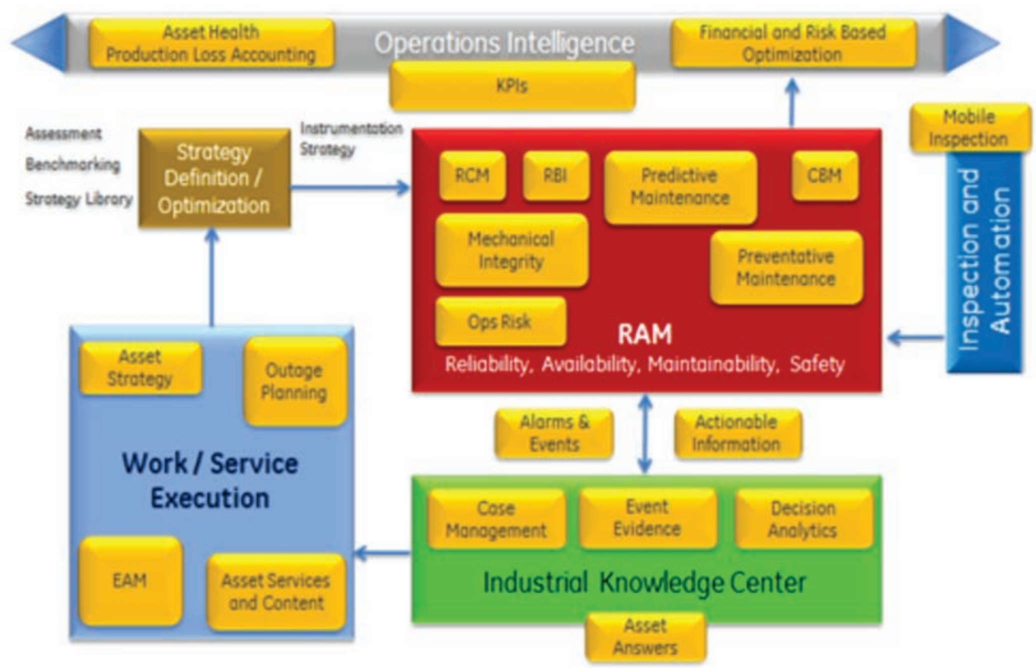


Fig. - 9: Architecture for an Integrated Assets & Operations Management

Though there can be best in class systems in place, however, without any integrated solution, it may really be difficult to answer some critical questions if there are problems w/a critical asset that might impact my production KPIs? With the kind of turnover in our industry, we can't keep track of what upgrades we've made to some of our equipment. Often, there isn't enough visibility across all the equipment and different systems in operation – that makes it hard for to prioritize actions. Plant operators need to meet production demands, make sure to keep costs in line and optimize performance across a single facility/across entire fleet of assets. If we could boost productivity by even a small percent, we could leverage it to expand our market. Firm's inability to know when capital outlays are required can wreak havoc on their financial plans.

APM customer story 1: *Early detection of sea pressure issue on offshore oil platform saves millions.*

$7.5M saved in potential lost production revenue, Avoided pump shutdown and operational failure, $365,000 repair costs avoided.

Water injection pumps on an offshore oil platform were used to inject water into a well to increase the number of barrels of crude oil being produced by the well. This particular oil platform had two of these water injection pumps, and seal pressures on the drive end and non-drive end sides on one of the water injection pumps quickly dropped from expected values.

Fig. - 9: Seal pressure deviations v/s expected values

Once made aware of the issue, the facility found that the cause of these deviations was that the seal had begun to leak or the make-up pump was not controlling properly. These seals are pressurized dual seals and use barrier fluid to ensure that the water being pumped into the well stays contained in the pump. It is very important to maintain a barrier pressure on the seal that is above the product seal chamber pressure. If the seal pressure had continued to drop, grit could have been embedded in the seal, causing a rapid failure of the seal and a shutdown of the pump. The other pump had recently failed due to the same type of seal issue and had to be sent for repair at a cost of $365,000.

Early notification of a potential seal failure enabled an oil and gas facility to make a simple operational change and prevent rapid failure of the seal and a shutdown of its pump. It avoided significant production losses and hence, saved millions in potential revenue losses.

APM customer story 2: *Early detection and pinpointed diagnostic of steam turbine rotor rub with seal helped optimize operating conditions and continue plant operations for 32 months without load reduction avoiding millions of unplanned downtime cost.*

In one of process plant, steam turbine driving the compressor, shown the sign of periodic vibration excursions. Plant operators contacted GE Machinery Diagnostic engineer for remote dial and analysis of the turbine behavior. With the help of online vibration monitoring system and software, it was diagnosed that there is steam turbine rotor rub. This is soft rub and possibly due to leaking oil vapors getting carbonized and creating physical contact

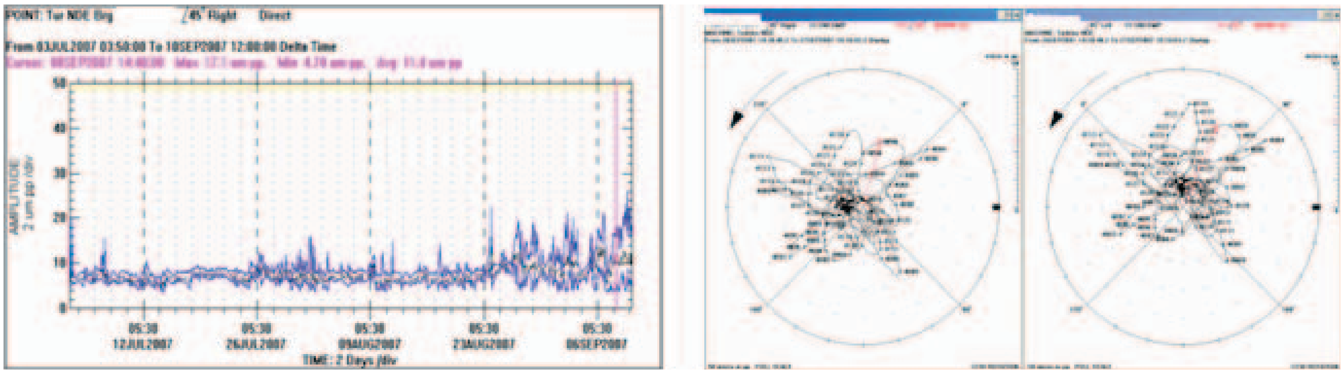


Fig. - 10: Trend & polar plots showing vibration amplitude excursions and related 1X phase changes

with rotor.

After troubleshooting and analysis, turbine was continued operation under strict process control, so as the operating condition, speed etc. is within the narrow operational boundaries. Further, necessary spares, manpower were arranged, so as if required, turbine maintenance can be planned in shortest possible time. Plant operators could run the unit in such condition till almost 32 months. They replaced the seals & rotor in planned plant shutdown owning to some other reason.

This demonstrate that installed software, was helpful first in pin pointedly diagnosing the vibration excursion reason and secondly helped to continuously monitor the risk of operation until opportunity based shutdown was available. This helped plant operators to save millions of dollars of unplanned shutdown related production lost.

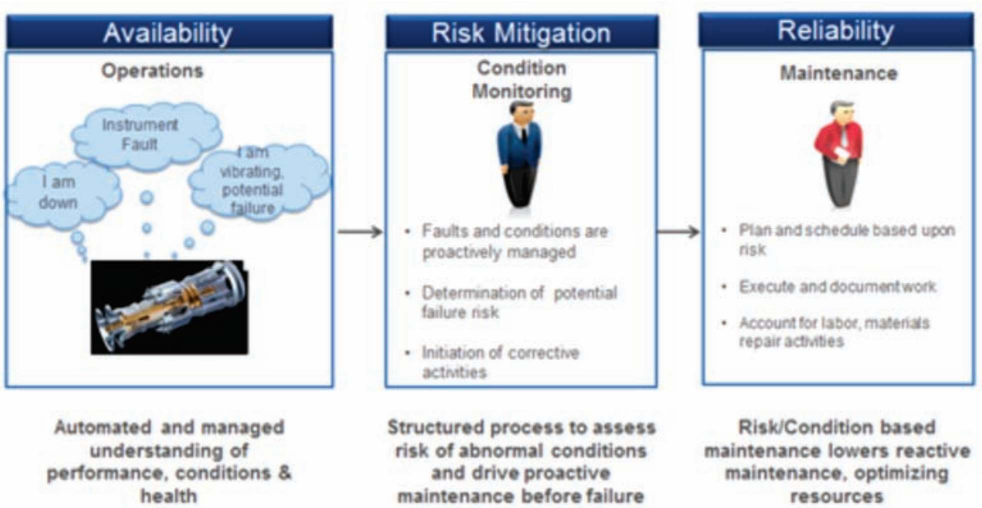


Fig. - 10: Need of Integrated maintenance work processes

Plant operators need equipment availability to the highest to perform on their production targets. While, they achieve balance between operation v/s plant shut down, they need complete understanding about the true health of the assets to mitigate the risk of operation. And often such risk mitigation analysis is provided by Condition Monitoring teams. Based on risk assessment & fault analysis, maintenance team schedules and performs the maintenance to ensure that equipment reliability is enhanced with minimum spend on maintenance.

APM customer story 3: Bruce Power has found that through a continuous regime of identifying maintenance-related work process improvement opportunities using Meridium APM, the company can increase the life of their existing assets, improve plant reliability and availability and increase the amount of power pumped into the grid. Bruce Power Optimizes Availability to Power 30% of Ontario at 30% Lower Average Cost by effective implementation of Meridium APM solution.

Bruce Power operates the world's largest nuclear generating facility and is the source of roughly 30% of Ontario's electricity. The company's site in Tiverton, Ontario is home to eight CANDU reactors, each capable of producing up to 800 megawatts. The nuclear power industry is struggling to balance rapidly increasing demand with the costs and safety measures required to support an aging equipment base. Bruce Power identified scheduled maintenance activities as a source for efficiency gains enabling increased availability. Specifically, the company had more scheduled maintenance activities than capacity for timely execution. Bruce Power was able to identify and implement, on a continuous basis, maintenance-related work process improvements to increase availability, while continuing to meet the company's high safety standards. Using Meridium, the company uses a risk-based approach to determine optimal maintenance intervals for its assets.

Hence, there is definitely a value for real-time Equipment Management Solution. The solution combines Work identification & condition monitoring systems with Asset Performance, Health Management and Production Loss Accounting system to help in asset-intensive industries to optimize their productivity.

Use Case	Solution	Value
Condition Based Maintenance (CBM)	Automated condition and health monitoring integrated to maintenance processes	Optimize Maintenance
Production Loss Management	Track and monitor downtime and production loss to have visibility needed to enhance reliability strategy	Improve Availability
Risk and Integrity Monitoring	Monitor critical process variables that impact risk and integrity assessments	Reduce Uncertainty

Table - 3: Value Scenario for integrated work processes

The integrated solution provides a holistic and quantifiable view of Operations, Maintenance, Production Availability and Overall Operating Performance. Data is aggregated primarily from Operational Historians – Process Data, Asset Condition Monitoring & other Condition Monitoring systems and Enterprise Asset Management - Maintenance Management & Production Data.

Use of risk based principles drives assessment of faults and conditions based upon potential organizational impact to ensure appropriate actions are taken to minimize consequences. The solution brings new insights into why things fail, where the bad actors are, and emerging failure symptoms and derives Key Performance Indicators of Operational Performance & Risk.

Key Benefits of APM:

GETTING TO NO UNPLANNED DOWNTIME: Unplanned downtime is costly. A single data center outage can cost $7,900/minute. A nine-day power outage in Queens, NY, cost local businesses $111 million in damages. In IT, much like in any other sector, 99.999% of uptime is the ultimate goal. What if unplanned downtime was just a memory?

GREATER PRODUCTIVITY: In a world of no unplanned downtime, machines would be interconnected, constantly exchanging information about one another's status. Thus, each machine would function almost optimally, sending alerts to predict when replacement or repair will be needed. The result: improved productivity.

NO MORE WAITING: In healthcare, real-time communication between machines would facilitate an improved patient experience and throughput. The Aventura Medical Center in Florida, for example, has employed Industrial Internet solutions to cut ER wait times by 68% in just nine months.

EARLY WARNINGS: With machines giving early notice of problems, engineers will use data to craft better interventions to blunt or forestall crises. Risk management will orient more towards early warning systems, although "black-swan" risks would still require what-if strategies to be in place.

POWERFUL OUTCOMES: Power outages cost $80 billion in the US alone. Each year, 700 people die from heat waves in the US—a number that could rise to 5,000 by 2050, according to the CDC. Reducing unplanned downtime in the electricity sector would not only increase productivity, it could also save lives.

CONCLUSION:

The realization of the Industrial Internet is not a foregone conclusion. Key enablers, catalysts and supporting conditions will be needed for meshing the physical world of machines with the digital world of data and analytics to reach its full potential. Some of the most important elements will clearly be continued progress across innovation, and vigorous cyber security management, enabling infrastructure and new talent development.

Data is the difference. Asset Performance Management, or APM, helps asset-centric industrial companies reach breakthrough levels of performance with their assets by increasing availability, decreasing costs, and reducing operational risks. APM integrates the technologies of connectivity, data capture, integration, visualization, and analytics to support asset lifecycle management, remote monitoring, condition-based and predictive maintenance, and real-time operator intelligence.

GE combines industrial domain expertise, cutting-edge technology, and advanced analytics to help industrial business get the right information to the right people at the right time. It unlocks the competitive advantage of the business.

BIOGRAPHICS

Pankajkumar Sharma is Director – Software & Services for Oil & Gas Digital Solutions of GE India. He graduated in Mechanical Engineering from M S University of Vadodara in 1998. Initial 5 years, he worked with IPCL-Dahej (now Reliance group of companies) in maintenance and condition monitoring of rotating/reciprocating machines. Since 2003, he is working with GE. Prior to his current assignment, he led Machinery Diagnostics Services of Bently NevadaTM for GE India. Under his leadership, GE India successfully completed "Vibration Analysis

Domain Expert Development Program" for ONGC and started 24x7 Remote Monitoring & Diagnostics Centre. He has published number of technical papers and articles in Orbit, ISA conferences, GETS, IORS and NSRD.

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Smart Terminal Automation & its Integration with Plant Control - Its Evolution & Challenges

Naimish Raval; General Manager - International Sales
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ABSTRACT

Automation of Liquid Hydrocarbon Terminals, over a period of 2 decades have evolved quite a bit, leveraging technology, offering wider spectrum of monitoring & control. At the same time, striking right balance (moderation) is much needed to reduce challenges and making it simpler. In this paper, its evolution, advancement and current state with challenges are elaborated.

KEYWORDS

Redundancy, Safety Integrity Level (SIL); Plant Control, Human Machine Interface, Fluid compensation, Meter Proving, Inventory Reconciliation, Interfaces, Safety & Security, MB Lal Committee Recommendations.

INTRODUCTION

Since the time, crude oil transportation & refining started scaling up, need of safe & secure liquid cargo management came into practice. There are mainly three era to discuss in Indian context; 1. Pre 1991; 2. 1992 to 2010 and 3. 2011 onwards. Each of the year mentioned, represents important milestone in the journey of Terminal Automation industry.

Before we go into this journey, lets quickly summarize, any typical mid to large size Automation of Liquid Terminals comprises of. Simpler way to imagine Terminal Automation is - think of upstream & bigger scale of retail distribution stations. It is not to be mixed or get confused with Retail automation of dispensing station.

Modern Terminal Automation System (TAS) comprises of ; Loading Rack Computer (LRC) Servers, Process & now Safety PLCs, Tank Farm Management (TFMS); Gantry automation, Access control, Safety interlocks, MOV/ ROSOV controls, interface with clients' ERP system, etc...

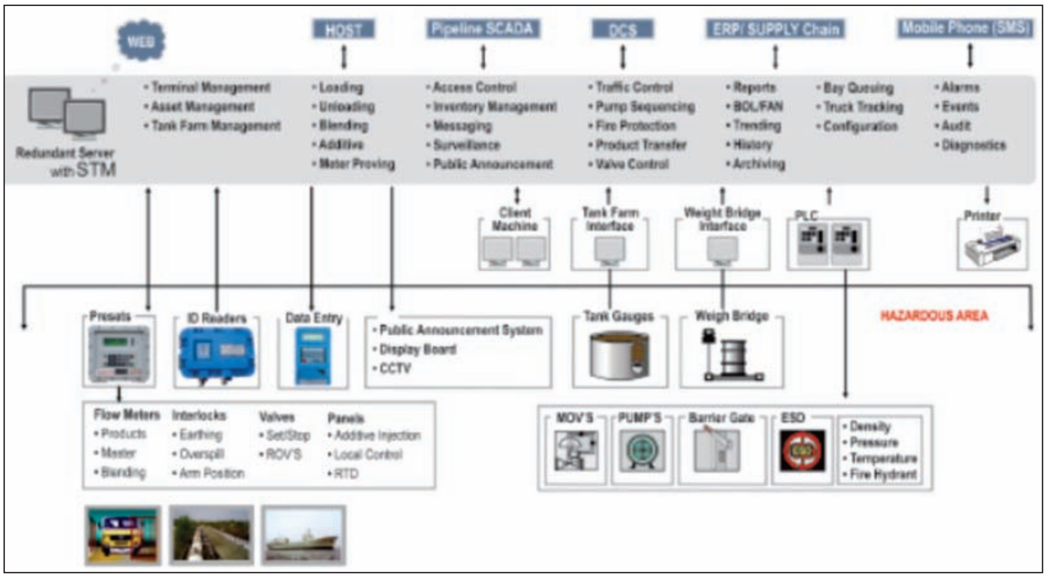
The Journey of Evolution

Pre - 1991:

While bulk refining and transportation came into practice, various instrumentation & process control equipment came up at the similar time, which has attracted Oil producers & Oil Majors (IOCs, NOCs) to implement basic process control and instrumentation. E.g. Positive Displacement / Turbine meters, basic Pre-set with actuated valves, level gauges, etc... Yet, mainframe computers and solid state electronics didn't come into industrial platform, but basic mechanical equipment, relay logics, pneumatic gauges, float type level detectors, etc.. were used. Obviously, there was not much electronic data storage and automation implemented in various parts of the world. North American & Western European countries were leading in the implementation of the basic automation concepts.

Post 1991:

As far as Indian petroleum industry is concerned, IOCL, being major PSU, having largest install base, conceptualized on introducing automation to their



Lets talk on three era mentioned above.

Terminals operation in 1991, they appointed BHPV as technical consultant and BYNL as EPC. Karnal depot (outskirts of Panipat) which was green field project was selected for automation by IOCL. GE-Advanced Sys-Tek (erstwhile Advanced Spectra-Tek, Indian JV of Spectra-Tek UK) was the automation system supplier. Simultaneously, BPCL also had taken similar initiative for its Vizag terminal. It ramp up in quick succession then for Bhatinda, KBPL TOPS (Siddhpur, Jodhpur, Jaipur) and so on. It was big cultural and mindset shift for Indian operators from dip stick manual intensive, gross-uncompensated measurement to PD meters & batch controller based dispensing. Many of us have seen NOCs top brass putting mammoth efforts to overcome inertia & strong resistance from operators, truckers due to A). Not understanding compensated dispensing of refined products B). Automation was sealing the possibilities of pilferages & prevailing malpractices. Like any change initially brings resistance and this also has seen major teething trouble for Automation to succeed in initial days. However, as NOCs started seeing operational excellence and increased efficiency due to automation, industry's adoption towards adaption speeded up. By now, other NOCs also started automating their major bulk terminals. At this point of time, TAS was pretty simpler redundant PC based servers (few DCS vendors tried with control system, though!), process PLC, mechanical / Servo gauges, gantry automation, access control system and ERP connectivity for remote loading.

Beyond 2010:

After Jaipur fire incidence in 2009, Petroleum ministry formed a committee led by Mr. M B Lal for recommending the required safety measures to safeguard highly hazardous liquid Terminals. Recommendations of this committee known as MBLC recommendation, came into force gradually from 2010 onwards. There are several changes to the erstwhile automation, suggested by MBLC. We will discuss them in coming sections.

From observations at various depots & past learning, MBLC came up with their recommendations after detail study of Indian terminals' operating procedures. Here, intent of this paper is not to discuss entire recommendations, we will touch upon instrumentation & automation related aspects listed in the recommendation. Below is the gist of the MBLC recommendations:

MBLC Recommendations:

Field Equipment

1. Remote Operated Shut Off Valve (ROSOV)
2. Electrohydraulic Actuator
3. Radar type tank farms with secondary Radar gauges
4. Anti-Overspill Protection System (AOPS) – HH & HHH alarms via Level switch on each tank
5. Hydrocarbon Detectors Point Type & Open Path Type
6. Mass Flow Meters for PLT transfer
7. Double Bleed And Block Valve (DBBV) With Electrical Actuator
8. MOV(TOBV With Electrical Actuator)
9. Rim Seal Fire Protection System
10. Wireless System –Repeaters
11. Wailing Siren
12. Air Compressor System

Control Room Equipment:

a) Safety PLC & its Associated panels, Ethernet Switch, etc..

b) RIM seal fire alarm panel

c) Clean Agent System (in CR)

d) UPS & Battery Bank for RIM seal FPS & Safety PLC system

e) OIC cum EWS, printer for Safety PLC system

f) OIC for RIM seal System

g) Wireless System- gateways

Obviously, above was much needed augmentation from safety perspectives. Truly, these changes have made today's terminal more secure. However, it heavily depends on "The Way We Work (WWW)", I mean to say here is, our safety & quality culture, how we interpret, understand & the spirit behind these recommendation and execute them keeping basic motive behind them. In next section, we will discuss challenges paused to the industry while implementing all good changes.

Challenges:

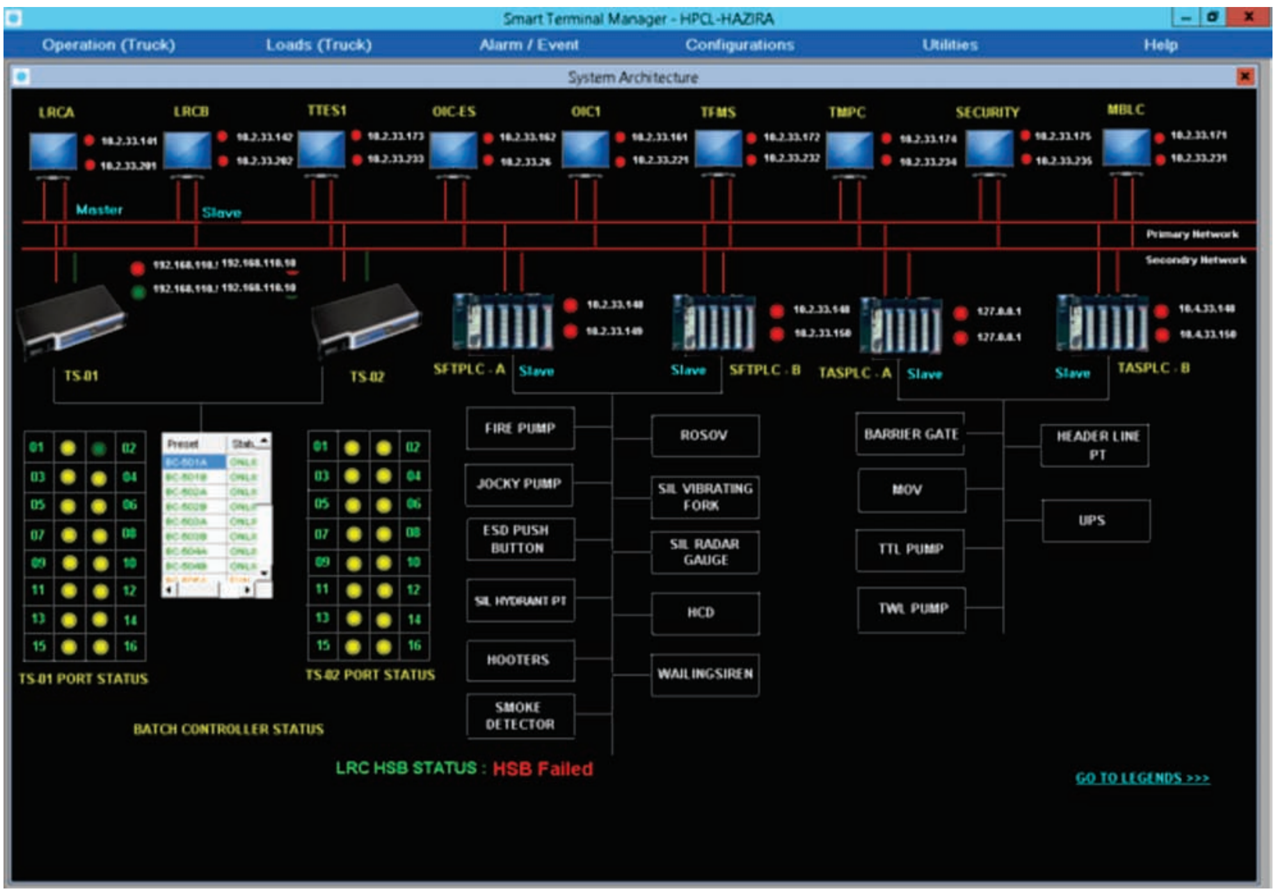
If we go to any terminal and take survey, feedback, we will get mix & polarized results. Certainly, there is much ground covered, if we look back and take reference point to 1991 or earlier. However, in due course, there are various challenges popped up due to increased scope of TAS suppliers, field work and timeline targets in implementing safety recommendations.

Today's automation, from engineering and safety perspective, is matured and well groomed. Having said that, challenges are mainly on implementation & in execution, equally by users & suppliers. There are increased subsystems & its interfaces, dependency on the existing equipment interface, upgradation needs due to obsolesces, etc.. There are high interdependence on many agencies. Existing supplier, contractors, users Engg, O&M groups, consultants, PMC / EPCs, etc… While implementing all learnings related to scope clarity, single point responsibility in the multiple agency environment, NOCs have started going for LSTK EPC approach to TAS suppliers. TAS suppliers scope gets skewed from their core competency to non-core area. When automation suppliers whose main strength is in control room and field instrumentation was expected to carry out almost like an EPC contractor which includes piping, civil, mechanical modifications, then implementation is bound to be impacted. At other end, in the quest of increased deal size (order value) TAS vendors have been overlooking into execution challenges and taking all sorts of non-core activities associated around automation. Adding to it, timing in which all PSU/NOC were tasked towards implementing MBCL recommendation, driven by ministry target is bringing quality vs quantity to the surface. From TAS vendors as well as end user perspective, if we summarize, there are following top challenges to address:

1. Understanding of core engineering & integration with other sub systems
2. Operational philosophy & safety logics
3. Change management both technically as well as commercially
4. Standardization of engineering
5. Understanding essence of MBLC recommendation & moderation
6. Handling non-core work part, which are highly site contractor dependent & labor intensive
7. Safely upgrade Brown field installations with minimal shutdown, within CDD

There is no simple quick fix to this, the way to continue cruising and exceling further is to have better planning, better communication & coordination. There are glaring success seen and also miserable failure too. It depends on both TAS vendors' engineering & integration capabilities as well as end users killer instinct to succeed amidst challenges.

If we list top pain areas of the terminal operators from instrumentation & control point of view, they



are :

Pains of Terminal Operators:

- o DOS / NT / UNIX based OS
- o Sub systems working in isolation (not integrated)
- o Obsolete Presets & other load rack instruments
- o PLC systems & integration issues
- o Service support of legacy systems
- o TAS software does NOT support Expandability/ Flexibility

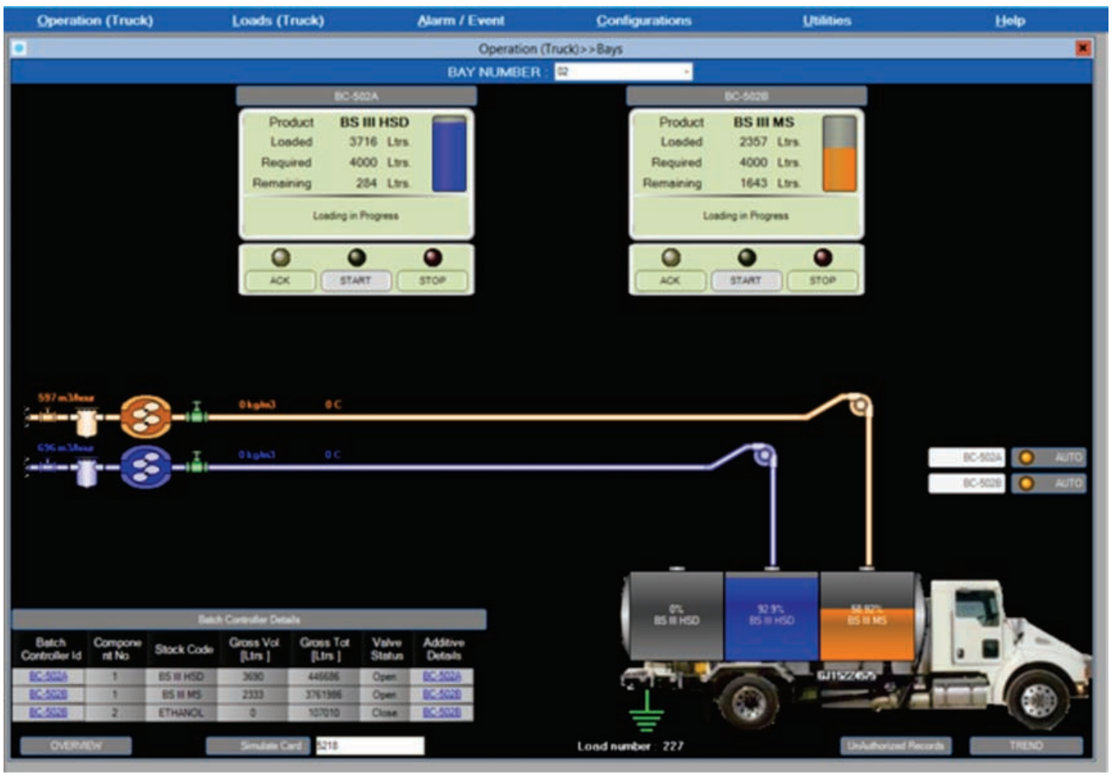
Now lets look at the “half glass full”, which is invariably worth noting at this point of time.

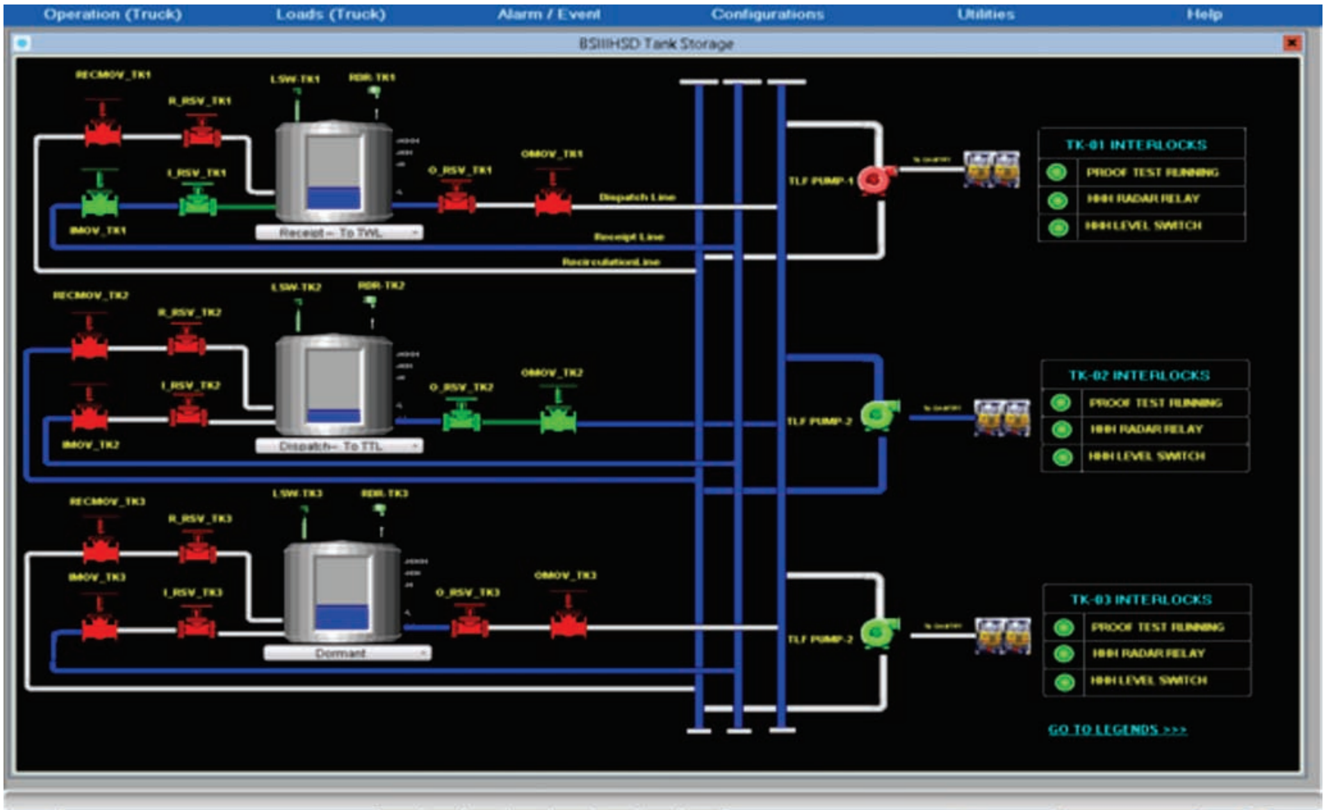
Today’s Smart Terminal

Latest Smart terminals have high speed server grade dual redundant LRCs in Hot Standby mode, with ability to completely switch over in few seconds. It has flexible & configurable HMI with real time updates from all sub systems in the range of 3-5 seconds. Its loaded with rich GUI based various configurable screens; complete monitoring of the terminal activities just a click away. Latest Cyber data security and Redundant Oracle / other database are updated real time basis for all transactions. In these many years, many installations and some of the system are such a stable & rugged that it can load continuously in three shifts. Terminals are easily loading of the order of 450-500 trucks a day (highest record in recent time is 695 trucks with 16 bays in 2 shifts at one of the Southern coastal depot). Blending & Additive injections are now common features.

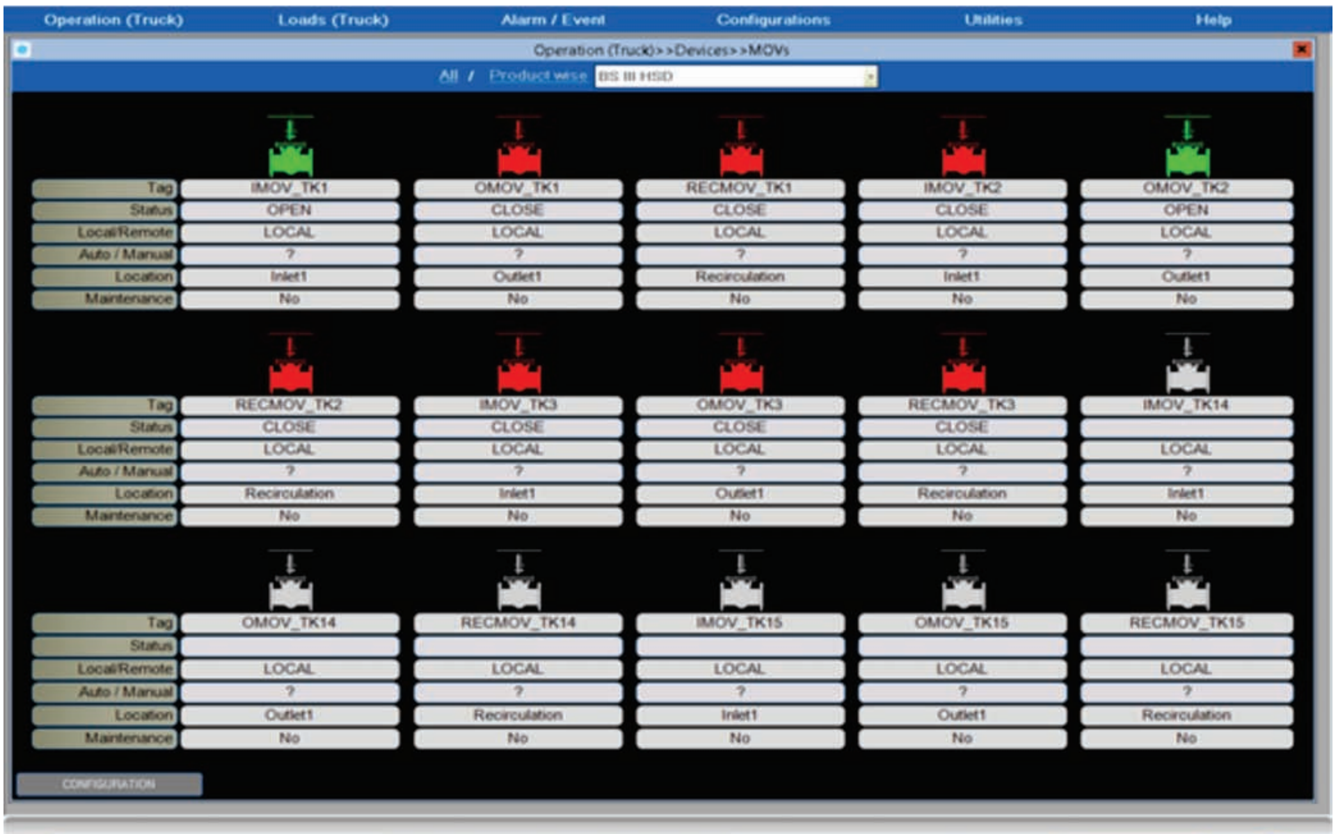
Leveraging various features & capabilities of the software, customers have further improvised smartness of the terminal by adding following features:

1. Auto Tank Truck (TT) queuing





Operation (Truck)
Loads (Truck)
Alarm / Event
Configurations
Utilities
Help
BSIIIHSD Tank Storage
RECMOV_TK1
R_RSV_TK1
LSW-TK1
RDR-TK1
I_RSV_TK1
IMOV_TK1
O_RSV_TK1
OMOV_TK1
Receipt→ To TWL
Dispatch Line
Receipt Line
Recirculation Line
TLF PUMP-1
TK-01 INTERLOCKS
PROOF TEST RUNNING
HHH RADAR RELAY
HHH LEVEL SWITCH
RECMOV_TK2
R_RSV_TK2
LSW-TK2
RDR-TK2
I_RSV_TK2
IMOV_TK2
O_RSV_TK2
OMOV_TK2
Dispatch→ To TTL
TLF PUMP-2
TK-02 INTERLOCKS
PROOF TEST RUNNING
HHH RADAR RELAY
HHH LEVEL SWITCH
RECMOV_TK3
R_RSV_TK3
LSW-TK3
RDR-TK3
IMOV_TK3
I_RSV_TK3
O_RSV_TK3
OMOV_TK3
Dormant
TLF PUMP-2
TK-03 INTERLOCKS
PROOF TEST RUNNING
HHH RADAR RELAY
HHH LEVEL SWITCH
GO TO LEGENDS >>>



Operation (Truck)
Loads (Truck)
Alarm / Event
Configurations
Utilities
Help
Operation (Truck)>>Devices>>MOVs
All / Product wise BS III HSD
Tag IMOV_TK1 OMOV_TK1 RECMOV_TK1 IMOV_TK2 OMOV_TK2
Status OPEN CLOSE CLOSE CLOSE OPEN
Local/Remote LOCAL LOCAL LOCAL LOCAL LOCAL
Auto / Manual ? ? ? ? ?
Location Inlet1 Outlet1 Recirculation Inlet1 Outlet1
Maintenance No No No No No
Tag RECMOV_TK2 IMOV_TK3 OMOV_TK3 RECMOV_TK3 IMOV_TK14
Status CLOSE CLOSE CLOSE CLOSE
Local/Remote LOCAL LOCAL LOCAL LOCAL LOCAL
Auto / Manual ? ? ? ? ?
Location Recirculation Inlet1 Outlet1 Recirculation Inlet1
Maintenance No No No No No
Tag OMOV_TK14 RECMOV_TK14 IMOV_TK15 OMOV_TK15 RECMOV_TK15
Status
Local/Remote LOCAL LOCAL LOCAL LOCAL LOCAL
Auto / Manual ? ? ? ? ?
Location Outlet1 Recirculation Inlet1 Outlet1 Recirculation
Maintenance No No No No No
CONFIGURATION

2. Enhanced ERP (SAP) interface

3. AUTO FAN generation

4. EDU integration with TT queueing

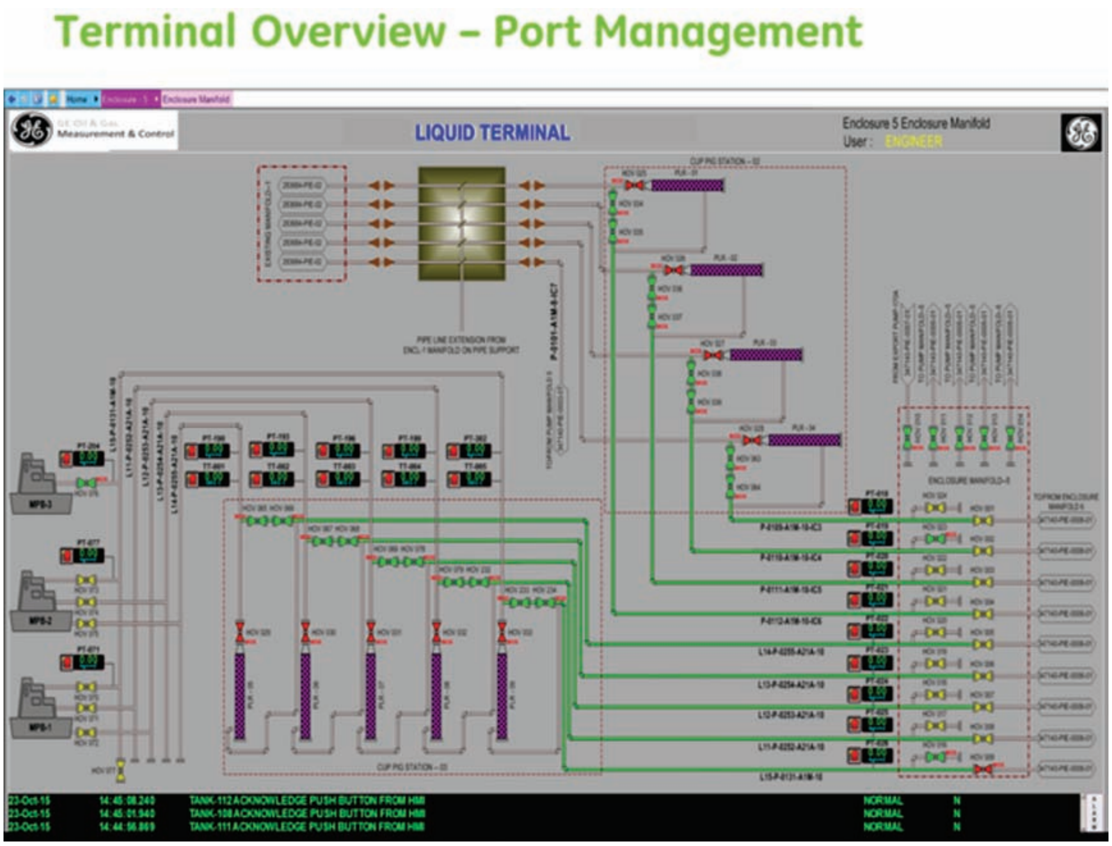
5. Mix Load density posting to SAP

However, main benefits of MBLC and further developments are on ROSOV, DBBV integration with TAS via Safety PLC. It is to be considered as major takeaway from whole learning journey.

Plant control & Further Integration

Imagination at its best – while we are getting smarter every day, we have been learning how to extract / exploit power of technology. Earlier, myth was – large TAS needs DCS platform. With latest main frame computers, PLCs, various software and application layers almost virtual or "hybrid" DCS solution has come up, which offers almost all the DCS functionality at the HMI level, while maintaining high speed data acquisition and control via PLCs with GBPS data transfer capabilities. There are several examples of extending TAS to pipeline control, port management, liquid cargo handling, OMS, MLM of refinery outlets, Port Terminals which requires complex line up from jetty to tank, inter tank transfer, load scheduling, etc…

There are many instances cropping up where pipeline control room PLC and TAS PLC to be integrated, two different suppliers' safety & TAS system to be interfaced, phase 1 & phase 2 of different TAS suppliers to be seamlessly brought under one LRC, existing field instruments to be connected to newer system without changing field wiring or disturbing routine operations, etc… Here, new tools, digital thinking, applications, development and resilience blended with deep subject matter knowledge will take us to new height in achieving the operational



excellence. While we can go endlessly in leveraging technology, few cautions will be recommended while doing so,

a. Fit to the purpose.

Ask yourself, if this is really required for ease of operation? Since, asking all the possible features, (which are now a days possible), but it can take up to over engineering or loading system too much for not a significant gain.

b. What are the consequences

Customization comes at a cost. Maintaining the software release, having trained resources, time justified in developing, future upgradability, etc.. to be viewed in totality before we look for the features.

c. Keep it Simple

Again, in line with Fit to the purpose, e.g. consider if SIL level 2 is adequate OR we must go for SIL 3 just because it is available... Technology debate can be taken with final operational and business goals in mind.

Conclusion:

In line with technological advancement, there are various good avenues available in terms of achieving better inventory reconciliation, faster turnaround and hence increased throughputs, which ultimately lead towards achieving operational excellence with safe and secure operation, which will reduce impact of hazardous nature of the environment, we are exposed to.

For better success following key points to remember : –

- Moderation / striking right balance of technology
- Leverage the strength of automation
- Execute with right scope while implement learning
- Ownership & operational excellence by every stakeholder.

ACRONYMS:

TAS	Terminal Automation System
LRC	Load Rack Computers
SIL	Safety Integrity Level
MBLC	M B Lal Committee
TFMS	Tank Farm Management System
MOV	Motor Operated valve
ROSOV	Remote Operated Shut Off valve
DBBV	Double Block & Bleed Valve
IOC	International Oil Companies
NOC	National Oil Companies
BHPV	Bharat Heavy Plates & Vessels
BYNL	Bharat Yantra Nigam Ltd
KBPL	Kandla Bhatinda Pipe Line
PLT	Pile Line Transfer
TOPs	Tap Off Points
AOPS	Anti Overspill Protection System
CDD	Contractual Delivery Date
DCS	Distributed Control System
PLC	Programmable Logic Controller

FAN	Filling Advise Note
MLM	Material Logistic Movement
OMS	Oil Movement & Storage
GUI	Graphical User Interface
HMI	Human Machine Interface

REFERENCES

M B Lal Committee Reports

GE Advanced Systek FDS

BIOGRAPHY

Naimish Raval - General Manager; international sales for GE-Advanced Systek is BE (Electronics & Communication) 1991, MBA 2002; is having vast experience in the field of custody transfer Metering of Oil & Gas, Terminal Automation, for 25 years. Prior to this role, he worked as Business Head of GE-Advanced Systek, Sr. Business dev. Manager with Emerson Process Management, Singapore for Asia Pacific region; Sr. Manager at Daniel Measurement & Control India, etc.. He has jointly presented two papers on Smart Meter verification at NEL SEA Malaysia in 2009 & Master Meter proving for Coriolis & Ultrasonic meters at Flotekg at FCRI India 2011.

HAWK FIBRE OPTIC SYSTEM FOR WATER, OIL AND GAS PIPELINE LEAKAGE DETECTION

SUBHENDU ROY
Hawk Measurement Systems Pty. Ltd.

ABSTRACT

The Use of Fiber Optic Based Leakage Detection System for Pipelines Results in Significant Technical and Economic Benefits and Opens up Additional Unique Technical Possibilities Like Leakage, Security, Equipment Integrity, etc.

INTRODUCTION

Flowlines, pipelines, or gas lines often cross hazardous environmental areas from the point of view of natural exposures, such as landslides and earthquakes, and from the point of view of third-party influences such as vandalism or obstruction. These hazards can significantly change the original structural functioning of the flowline, leading to damage, leakage, and failure with serious economic and ecologic consequences. Furthermore, the operational conditions of the pipeline itself can induce additional wearing or even damage.

The structural and functional monitoring can significantly improve the pipeline management and safety. Providing regularly with parameters featuring the structural and functional conditions of the flowline, monitoring can help (1) prevent the failure, (2) detect the problem and its position in time and (3) undertake maintenance and repair activities in time. Thus the safety is increased, maintenance cost is optimized, and economic losses are decreased. Typical structural parameters to be monitored are strain and curvature, while the most interesting functional parameters are temperature distribution, leakage, and third-party intrusion.

Since the flowlines are usually tubular structures with kilometric lengths, structural monitoring in full extent is an issue itself. The use of the discrete sensors, short- or long-gauge, is practically impossible because it requires the installation of thousands of sensors and very complex cabling and data acquisition systems raising the monitoring costs. Therefore, the applicability of the discrete sensors is rather limited to some

chosen cross sections or segments of the flowline, but not extended to full length monitoring. Other current monitoring methods include flow measurements at the beginning and end of the pipeline, offering an indication of the presence of a leak, but no information on its location.

Recent developments of distributed optical fiber strain and temperature sensing techniques based on the optical scattering effect promise to provide cost-effective tools allowing monitoring over kilometric distances. Thus, using a limited number of very long sensors it is possible to monitor structural and functional behavior of flowlines with a high measure and spatial resolution at a reasonable cost.

The aim of this paper is to present on-site applications of an innovative distributed sensing system. Hawk Fiber Optic Sensing (FOS) Is A Distributed Multiple Parameter Detection With Fiber Optic Sensors. Distributed fiber-optic sensors are an attractive alternative to multiplexed point sensors, because a single fiber-optic cable can potentially replace thousands of individual sensors, dramatically simplifying sensor installation and readout.

Hawk FOS Comprises Distributed Acoustic Sensing (DAS), Distributed Temperature Sensing (DTS), Distributed Strain Sensing (DSS) And Distributed Pressure Sensing (DPS). The Multiple Parameter Detection of Hawk FOS Improves Detection Accuracy and Reduces the Likelihood of False Alarms.

When a pulse of light travels down an optical fibre, a small amount of the light is naturally backscattered (through Rayleigh, Brillouin and Raman scattering) and returns to the sensor unit. The nature of this scattered light is affected by tiny strain events within the optical fibre structure which themselves are determined by the localised acoustic or seismic environment. By recording the returning signal against time, a measurement of the acoustic field all along the fibre can be determined. Raman scattering occurs due to thermally influenced molecular vibrations, while Brillouin scattering occurs due to thermally excited acoustic waves in the GHz range present in the silica fibre. The scattered components appear symmetrically on both sides at higher (Stokes components) and lower (anti-Stokes components) wavelengths as shown in Fig. 1.

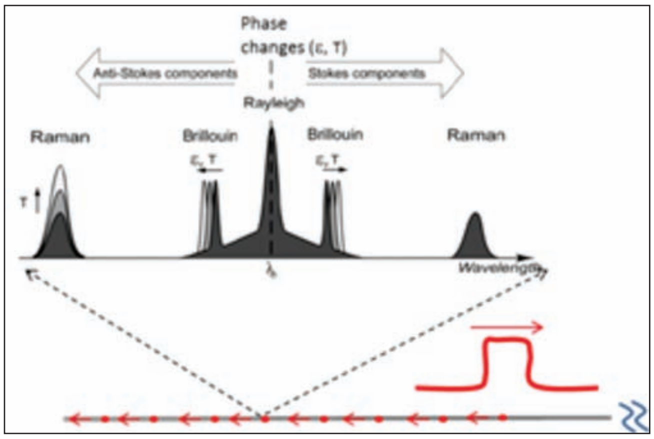


Fig. 1 Backscatter light from an optical fibre1.

The wavelength (or frequency) of the Raman peaks are fixed, but the intensity of the anti-Stokes component is temperature dependent while the intensity of the Stokes component is unaffected by temperature changes. Consequently, by comparing the two Raman peaks, the temperature information at the scattering location can be calculated.

The wavelength (or frequency) of the Brillouin peaks depend on the temperature and strain at the scattering location. Thus, the wavelength (or frequency) of the Brillouin peaks is shifted if the temperature or strain changes. This is called the Brillouin frequency shift. Brillouin optical time-domain reflectometry (BOTDR) or Brillouin optical time-domain analyser (BOTDA) used to detect temperature and strain through detecting the Brillouin frequency shift. BOTDA has higher signal to noise ratio since it uses stimulated Brillouin scattering.

The phase of Rayleigh scattering is affected by strain and temperature at the scattering location. Coherent optical time-domain reflectometry (COTDR) uses optical pulses from a narrow line width, high coherence laser to detect the phase of Rayleigh scattering. When an optical pulse is launched into a single mode optical fibre, the backward Rayleigh scattering light will interfere with each other causing signal ripples that superimpose the loss trace that could normally be obtained from a conventional OTDR. These ripples, because they are related to the fixed Rayleigh scatter sites within a fibre, are static as long as the fibre is static. If the fibre experiences any perturbations, or external forces, which strain the fibre, the positions of the scatter sites change. This in turn changes the interferometric induced ripples. By detecting the change of ripples, COTDR could detect acoustic events including acoustic signal waveform or spectrum continuously along 50 km long optical fibre.

THE SYSTEM DESIGN

The system can be configured to produce both single-ended and double-ended measurements. The minimum measurement time is 1 second (approx.)

Since Rayleigh, Raman and Brillouin scattering all exist in the back scattered light, we design a system using optical time/frequency-domain reflectometry/analyser to detect Rayleigh, Raman and Brillouin scattering. The system could switch between COTDR, Raman optical frequency-domain reflectometry (ROFDR) and BOTDA for distributed acoustic wave, temperature and strain sensing using a single mode fibre (SMF).

The advantages of such design:

- The system is flexible in interrogating acoustic wave signal, temperature and strain. Coherent OTDR are routinely monitoring the sound, strain and temperature gradient along the optical fibre. When slow-changed strain and temperature gradient (<10 Hz) are detected, BOTDA and temperature/strain differentiation technique could be used to specify absolute temperature and strain change value.

- Sensing fibre, lasers and optical amplifier can be shared for acoustic wave signal, temperature and strain sensing.

- The sensor is distributed sensor. Therefore all the positions along the optical fibre are monitored by the system with spatial resolution about several meters.

- Old buried telecommunication fibre can also be interrogated by the system.

2.1 COTDR for distributed acoustic wave sensing

A narrow line-width CW laser with wavelength of 1550.12 nm and line-width < 2 kHz is split into signal and local oscillator through a coupler (reasons for narrow line-width: the coherent length of laser needs to be longer than double the detection length of 50 km so that the backward Rayleigh scattering light and local oscillator light are coherently added in the balanced detector, enhancing detected signal intensity. Laser relative intensity noise and phase noise which directly contribute to the noise floor of detection signal are reduced). An electronic optic modulator (EOM) (or an acoustic-optic modulator (AOM)) modulate the CW laser light into optical pulses with repetition rate of 2-200KHz and pulse width of 10-1000ns, and also shift the frequency of light by about 100-400 MHz. The optical pulses are amplified by an EDFA. Optical filter is used to remove amplified spontaneous emission (ASE) noise from the amplified laser beam. Then the optical pulses is sent to the sensing fibre. The backward scattering light can be switched to any of COTDR, ROFDR or BOTDA part to be interrogated.

In COTDR interrogation system, Rayleigh scattering light is filtered out from the backward scattered light by an optical filter and mixed with local oscillator light, where the Rayleigh interferometric ripples are detected by a balance detector. The frequency of laser light is shifted by an IF frequency (100-400 MHz) through modulation of EOM, so the frequency of scattering light is shifted by an IF frequency. Thus the balance detector detects the interferometric ripples mixed with the IF frequency signal. An IF bandpass electronic filter (Band pass, central frequency equal to the modulation frequency of EOM 100-400 MHz, band width 100 kHz) selected the IF signal mixed with the interferometric ripples after the balance detector, which is then mixed with the modulation signal of EOM in a mixer and output signal was brought down to low frequency interferometric ripples. Low pass electronic filter (with bandwidth of 100 kHz) filters the interferometric ripples out. Moving averaging and moving differential (look Ref 2 for detail) are used to further reduce the noise in

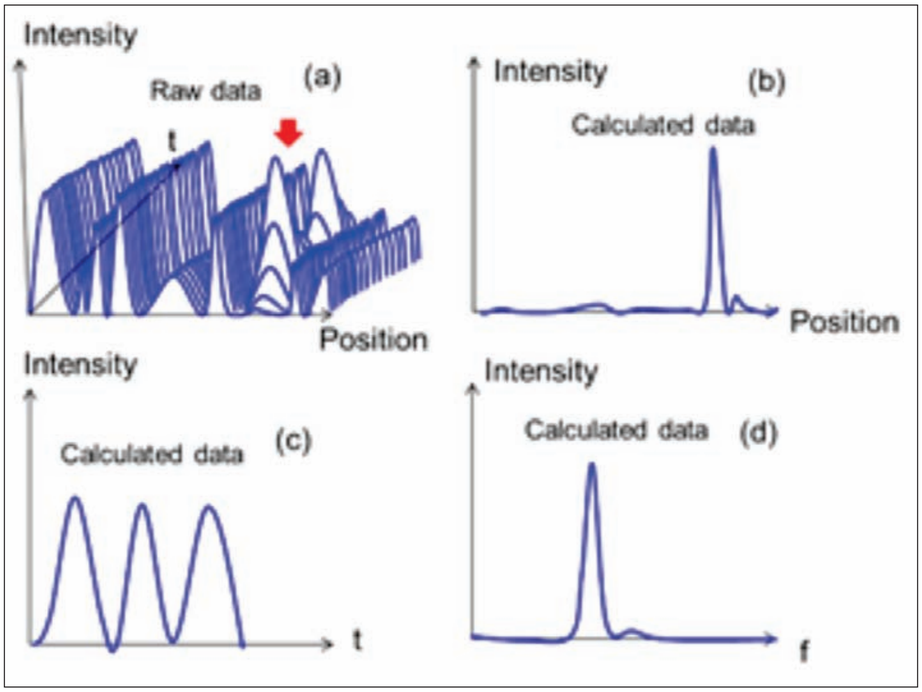


Fig. 3 Data collection of COTDR. (a) Detected interferometric signal (b) interferometric ripple variation peak at different positions (c) Acoustic signal waveform. (d) Acoustic signal spectrum

detected ripples2.

Fig. 3(a) shows the interferometric signal. These ripples, because they are related to the fixed Rayleigh scatter sites within a fibre, are static as long as the fibre is static. If an acoustic wave impacts on the sensing fibre (as shown by a red arrow), the ripple at the position where the acoustic wave affects the sensing fibre starts to change due to the phase change of light induced by the variation of strain. The interferometric signal intensity variation is processed and maximum intensity change along the position of optical fibre is calculated (Fig. 3(b)). Acoustic signal waveform (Fig. 3(d)) and spectrum (Fig. 3(d)) at the position could be obtained by tracing the interferometric signal intensity variation.

Specification:

- One pulse sent to the sensing fibre corresponds to one raw trace of the interferometric signal (blue line in Fig. 3(a)). Therefore the computer synchronizes the detected signals with the pulses sent to the sensing fibre and uses time delay (or time of flight) to map the detected signal with the positions in the sensing fibre.
- Optical pulse: pulse width: 1-1000ns. Rise time <0.2 ns.
- For each raw trace of signal, there are 50,000 samples for 50 km detection
- The number for moving averaging and moving differential can be set up by the user in the software (range 1-200). Default is 1 which shows the raw traces of signal without averaging.
- For 50 km detection, the time for detecting each raw trace needs 0.5ms. Software and hardware processing delay should be much less than 0.5ms, so they can be negligible.

2.2 BOTDA for distributed strain and

temperature sensing

BOTDA involve launching a short pump pulse into one end of the sensing fibre and a CW (continuous wave) probe beam into the other end. The frequency difference between the two lasers could be set to a particular value corresponding to the Brillouin frequency of the optical fibres, and the CW probe would experience gain varying along the fibre. This gain as a function of position along the fibre could thus be determined by the time dependence of the detected CW light. By measuring the time dependent CW signal over a wide range of frequency differences between the pump and probe by sweeping the frequency of the pump laser, the Brillouin frequency for each fibre location could be determined via pre-calibration as shown in Fig. 4 (a). This allowed us to establish the strain or temperature distribution along the entire fibre length as shown in Fig. 4 (b):

$$\Delta f= C_\varepsilon\Delta\varepsilon+ C_t\Delta T$$

(1) Moving averaging is used to reduce the noise floor2.

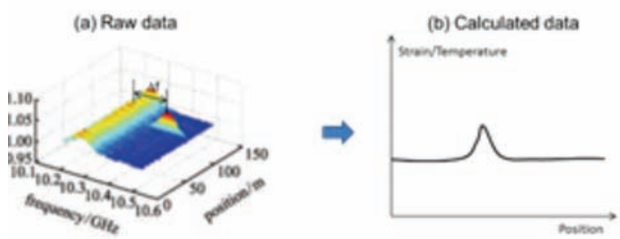


Fig. 4 (a) Optical intensity distribution of probe laser along different positions of optical fibre for different frequency separation between count-propagating probe light and pump light (raw data)3. (b) Calculated strain along different positions using the data in (a).

Specification:

- Optical pulse: pulse width: 1-1000ns. Rise time <0.2 ns.
- Pump laser: λ=1550.12nm, P=10 mW. After EDFA, the pulse peak power is about 800mW.
- Probe laser: λ=1550.2 nm, P=10 mW. Wavelength difference between pump and probe laser is 0.08nm (or 10 GHz).
- A 12 GHz bandwidth high-speed detector is used to measure the beating signal of the pump and probe waves, which provides feedback to the frequency counter to lock their frequency difference.
- Sweep the frequency of pump laser. First coarsely sweep in long range (-1 to 2 GHz) to find out Brillouin frequency value of SMF28 and large effective area fibre (LEAF) fibre respectively. Then around the Brillouin frequencies, finely sweep with high resolution around the two Brillouin frequency peaks of SMF28 and LEAF fibre.
- Two kinds of fibre with different Brillouin frequency shifts, SMF-28 and LEAF, are used as sensing fibre, so the effective Brillouin interaction length and the pump depletion are reduced. In addition, because the sensing fibre includes different types of fibres with different Brillouin frequency shifts, the spontaneous Brillouin scattering cannot accumulate over the whole sensing fibre, which is another advantage using 2 fibres in the sensing range.
- For every frequency, there is one trace showing the intensity of probe light versus fibre position as shown Fig. 5 (blue line). For each trace there are 50,000 samples for 50 km detection. The time for completing one trace measurement equals the time that a pulse completes one round trip of the fibre, i.e. 0.5 ms for 50 km sensing fibre.

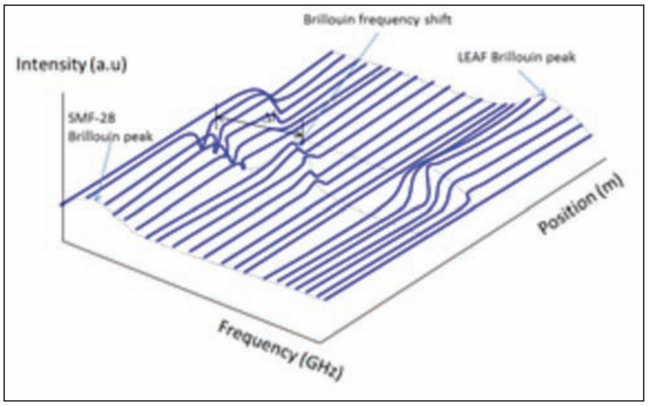


Fig.5 Brillouin peak obtained through sweeping frequency of pump laser

- Based on Fig. 5 (obtained raw data), find the Brillouin peak frequencies at different positions and display the Brillouin peak frequency trace. The Brillouin peak frequency trace is converted into strain/temperature trace (Fig. 4(b)) through calibration (1).

- Wavelength of pump laser is swept by changing the control voltage of the Piezo driver of the pump laser. The Relation of tuning frequency and voltage is 2000MHz/V. The finest sweep step: 0.1 MHz (50μV). Voltage control range: 0-5V. Software handles fine sweeping the frequencies at 2 Brillouin components from SMF-28 and LEAF fibre and coarse sweeping the frequencies between 2 Brillouin components as shown in Fig. 6, in order to save data acquisition time.

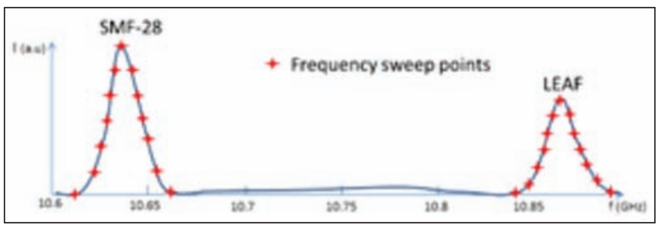


Fig. 6 Brillouin peak from SMF-28 and LEAF fibre

- The Brillouin frequency shift of SMF28 and LEAF is 10,867 and 10,645 MHz. Brillouin line width 30MHz.

- LEAF: Temperature coefficients C_t: 1.03±0.081 MHz/^{0}C, Strain coefficients C_ε: 0.051±0.001 MHz/με (From thesis[5], λ=1533.17nm).
- SMF-28: Temperature coefficients C_t 1.26 MHz/^{0}C, Strain coefficients C_ε 0.056 MHz/με (wavelength unknown, from ref4). Temperature coefficients C_t 1.07±0.070 MHz/^{0}C, Strain coefficients C_ε 0.048±0.003 MHz/με (From thesis[5], λ= 1533.17nm).
- The number for averaging can be set up by user in the software (range 1-20000). Default is 1 which shows the raw traces of signal without averaging.

2.3 Differentiate temperature and strain

In BOTDA, both temperature and strain will vary the Brillouin frequency shift. To differentiate temperature and strain, two techniques, Raman OFDR to detect temperature only in sensing fibre or applying two kinds of sensing fibres in BOTDA, could be used.

(a) Raman OFDR for distributing temperature sensing (Option1)

The distributed temperature along the optical fibre is detected by Raman OFDR technique. The sensing fibre is illuminated with a sinusoidal modulated pump beam (for shifting the frequency of light), and the Raman back-reflection is split into two channels: Stokes and anti-Stokes channel. The modulation frequency is sequentially increased by a fixed increment Δfm of 2 kHz from 0 Hz to 100 MHz region, and for each step, a measurement of the phase and amplitude of the sinusoidal Raman-backscattered light is made (Fig 7(a)). The frequency response is then transformed to the space domain by performing inverse Fourier transform on the received signal (Fig 7(b)). Then the distributed temperature is calculated (Fig 7(c)).

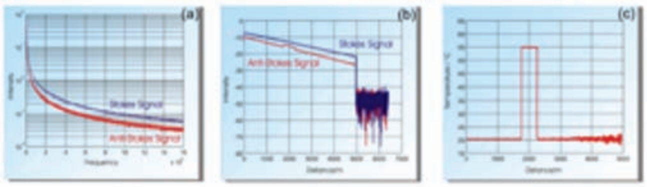


Fig. 7 (a) Traces of received anti-Stokes light signal intensity and Stokes signal intensity versus sweeping frequency6. (b) Fourier transform to time domain (c) Calculation of temperature profile

(b) Use different fibres in BOTDA (Option2)

Two single mode fibres with different core materials, i.t. different strain coefficients Cε1, Cε2 and temperature coefficients Ct1, Ct2, are used. By sweeping the Brillouin frequency shift of two fibres as shown in Fig. 4(a), the strain and temperature can be calculated by using the Brillouin frequency shift obtained from Fig. 4(a) and the strain coefficients Cε1 , Cε2 and temperature coefficients Ct1 , Ct2 of fibre 1 and fibre 2 used.

(2)

$$\begin{bmatrix}\Delta f_1\\ \Delta f_2\end{bmatrix} = \begin{bmatrix}C_{t1} & C_{\varepsilon 1}\\ C_{t2} & C_{\varepsilon 2}\end{bmatrix}\begin{bmatrix}\Delta T\\ \Delta\varepsilon\end{bmatrix} \qquad (2)$$

However,

- Temperature coefficient difference between SMF and LEAF fibre is about 10%, if the temperature accuracy is 0.3 0C for 50 km detection, for separating temperature and strain, the temperature accuracy would be 30C for 50 km detection.

- Other single mode fibre with different dopants could also be used. However, the strain coefficients and temperature coefficients of the fibre need to be investigated.

COMMUNICATION

Raw data, calculated data, warning and alarm data package will send from the computer in the field to the computer in central office continuously by wireless communication as shown in Fig. 8. The computer in central office updates data after receiving new data and saves the old data in hard disk.

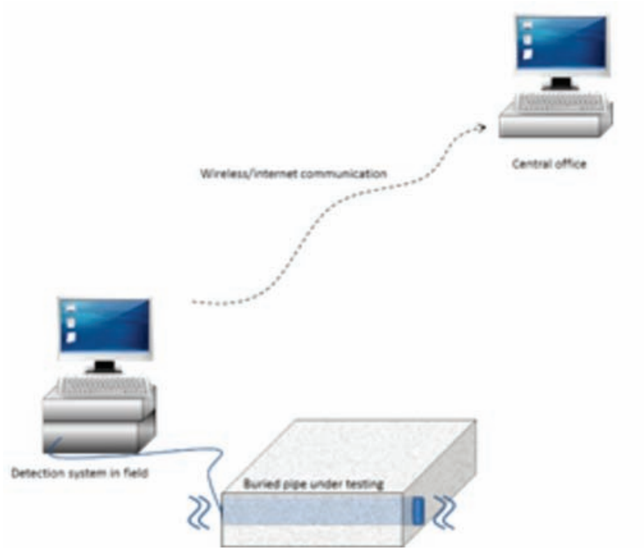


Fig. 8 data from the detection system in field is sent to central office through wireless communication

HMI - Alarms are managed through the Surveillance management application with a graphical interface showing the schematic layout of the pipeline network on a customised screen. On receipt of a warning, a message will alert the operator, and a marker will indicate the type of event and highlight its location on the pipeline network map. The operator will be presented with further information in the alarm window that includes the, time label and location. Every alarm will receive a unique alarm ID and all data associated with the alarm (including the signature data and operator notes) are stored locally on a database.

SPECIFICATION OF THE COMPUTER IN THE FIELD

- Continuously obtain raw data of detection system.
- Preform calculation of raw data and displaying the calculated data.
- Send received raw data and calculated data to the computer in central office
- Store history data (snap shot every minute/hour/day depending on the cost of data storage) in hard disk.

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Abstract of Technical Paper

Industrial growth, Improved productivity, Efficiency, sustainability through advancements in Metrology

A countries growth is directly proportional to the growth in the industry – whether it is Steel, Cement, Power, Refiner/Petrochemicals, Automotive, Pharma, Railways, Defence etc.

There are two approaches for the Industrial growth – one being increasing the production capacity to sustain the requirements but this requires a huge set-up and investment. Increasing the same though this by say 25% of the existing capacities would mean investments in tunes of several million crore of rupees.

The second approach towards the same is through minimizing the productions losses, increasing the quality, and optimizing the effeciency of existing units. This would require minimum investment and still ensure the increase in production quality and quantity to simillar ratio of say 20-25%.

This requires a controlled and quality conscious approach and is feasible through incorporation of the latest technologies in quality measures, testing, measuring capabilities and calibration procedures through useage of advancements in metrology field whether it is temperature, pressure, process, electrical, electronics.

This paper brings about the useage of quality products pertaining to precision temperature measurements and Universal calibration test benches complying to BS, IS, ISO9001, ISO14001, ISO17025 standards.

Power plants, cement, refineries, steel and simillar industries production and quality is ensured through temperature monitoring in the manufacturing process. If temperature is monitored precisely and all instruments being used are calibrated and performing well, we can optmize the manufacturing, production and quality.

Temperature as such plays an important role and needs to be monitored precisely and all instruments are required to be periodically tested and calibrated in house.

Is this important – Yes !!!

Being into Engineering field, we all know about the SI units – But are we aware that even with time there are new SI definitions now. International studies, research have resulted in an interest in redefining the kilogram, the ampere, the kelvin and the mole. As regards to temperature, there is a proposed new definition for the Kelvin -

The Kelvin is currently defined as the fraction 1⁄273.16 of the thermodynamic temperature of the triple point of water (exactly 0.01 °C)

Rather than have an "artefact" (WTP Cell) goal is to relate the Kelvin terms of the SI unit of energy, the joule by fixing the value of the Boltzmann constant k - which is simply the proportionality constant between temperature and thermal energy kT

A proposed new definition (definition is still being analysed internationally)

The kelvin is the change of thermodynamic temperature T that results in a change of the thermal energy kT by exactly 1.380 65X X × 10-23 *joule, where k is the Boltzmann constant*

However, the Boltzmann Constant is not known to a sufficient level, and number of experiments on going to determine the exact numerical value.

Temperature - Fixed Point : We have reached an advanced stage in metrology and these have also been redesigned to cater to the industrial requirements.

Unique - only realizable defining fixed point common to the Kelvin Thermodynamic Temperature Scale (KTTS) and the ITS-90

Calibration is divided in three sectors – industrial, secondary, primary. Advancements in temperature metrology has enabled the industry to have accuracte temperature systems incorporating the latest state-of-art technologies.

We see from Industry to Primary Metrology a demand for greater accuracy, a demand for more confidence and accordingly have responded with innovative new technologies which have enabled to have a CMC (at Gallium Fixed Point Cell) as 0.000,07°C (within 4 microK of worlds best reference cell).

Temperature Primary Standards consist of :- ITS-90 Fixed Points, Standard Thermometers, Associated measuring Equipment

Secondary Calibration Equipment consist of :- Liquid Baths, Fluidized Furnace, High Temperature Furnaces, Thermometers, Measuring Instruments

Industrial Calibration Equipment consist of :- Dry Blocks, Smaller Liquid Baths, Probes, Indicators and Software and dataloggers. Here innovtive ideas are incorporated and designs of primary standards have been incorporated resulting in very accurate industrial calibration systems as there is always a demand for greater accuracy in industries

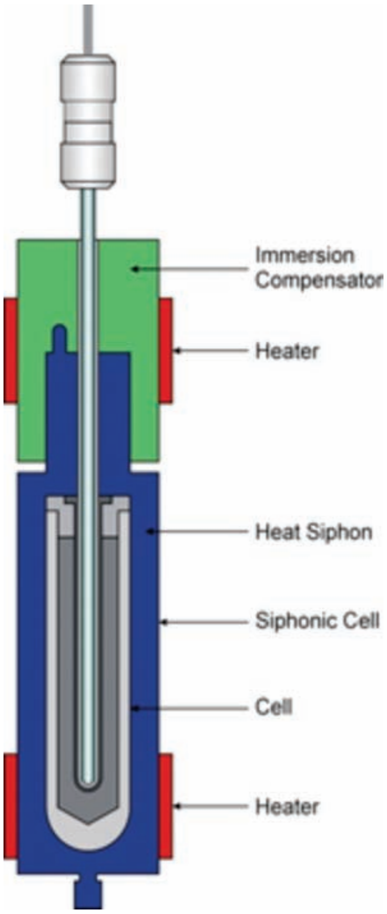
- For example Green Buildings - Calibrating Thermistors more accurately can save enormous amounts of money and protect the environment
- SImillarly in other applications also

Most calibrations are performed by comparing the unknown characteristics of the thermometer under test to a calibrated reference thermometer - But how are the reference thermometers calibrated? The answer is, in a series of known and fixed temperatures where pure substances (usually metals) melt or freeze

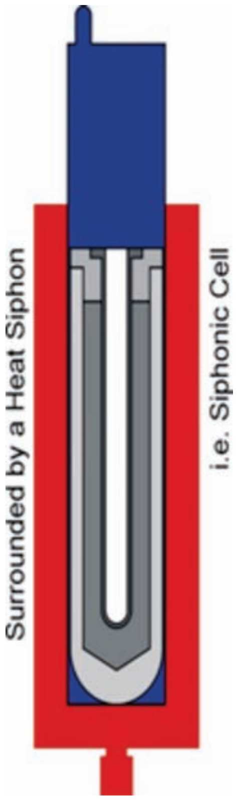
Three things are required before a thermometer can be calibrated at a fixed point : A fixed point cell (an ingot of pure metal inside a specially shaped graphite crucible), An apparatus or furnace to melt and freeze the ingot of metal uniformly and a precise indicator.

Technology has allowed an industrial dry block calibrator to be used as a ITS-90 fixed point realization bath thereby increasing the confidence level of plant, user, production. These are easy to use systems and also provide the flexibility for testing IR Thermometers, Thermal Imagers, Surface sensors, thermistors, RTD's, Thermocouples, Thermistors etc.

The shorter, smaller and costeffective fixed points are approximations to those in National Laboratories

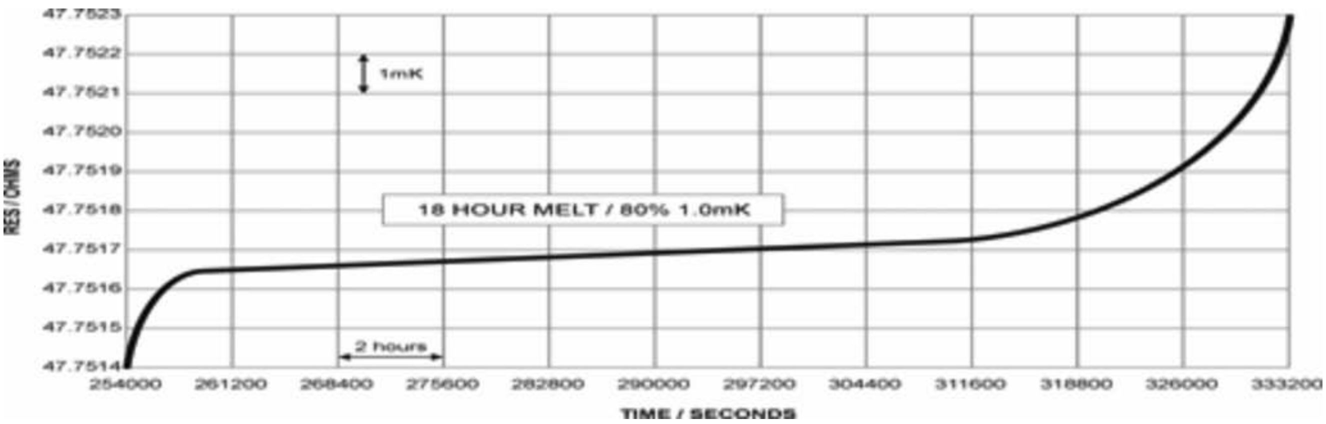


Technology has now gone one step ahead and now the cell and furnace become one and inseparable, the immersion necessary is calculated and compensated and innovative ISOTOWERS are available with even improved solution to fixed point calibration for industrial applications. The key to this design is a heat siphon in the shape of a Dewar with elongated inner tube. Siphonic Dewar is gradient-free so a cell inside will melt and freeze uniformly, the cell fits snugly inside and is sealed in place surrounded by 1 atmosphere of pure argon - The concept being called a Siphonic Cell (S.C.)



The ideal apparatus to surround a cell is a heat pipe or heat siphon. If the outer wall of a metal clad fixed point cell also becomes the inner wall of the heat siphon then a very simple structure of ideal thermal profile would result in above - Two heaters are used, the main heater for the Siphonic Dewar, the second heats the immersion compensator to the same temperature as the cell

The depth from metal surface to the bottom of the re-entrant tube is 180mm and this is inadequate for most industrial applications. The unit under test needs to go through an isothermal zone above the cell set to the cell's transition temperature. The Immersion Compensator actively provides the Isothermal Zone. The control temperature is set above the melt temperature – the cell melts. 0.1°C above yields a 30 hours melt. 0.2°C above 15 hours melt etc.



Other advancements / trends in temperature measurements as there has always been a demand for greater accuracy has resulted in very precise reference thermometers and indicators, scanners and software.

Higher Accuracy Measuring Systems : milliK which was a result as there was a demand for increased confidence in measurements to be made by the industries.

Just for your informationa nd knowledge – At primary level A Thermometry Bridge can work to 17µK at Wtp (0.000017ºC)

For industrial application we work at 0.001degC so call this as a millik - One thousandth of a ^{o}C, 0.001 ^{o}C is 1milli Kelvin, mK - milliK works to this level !!

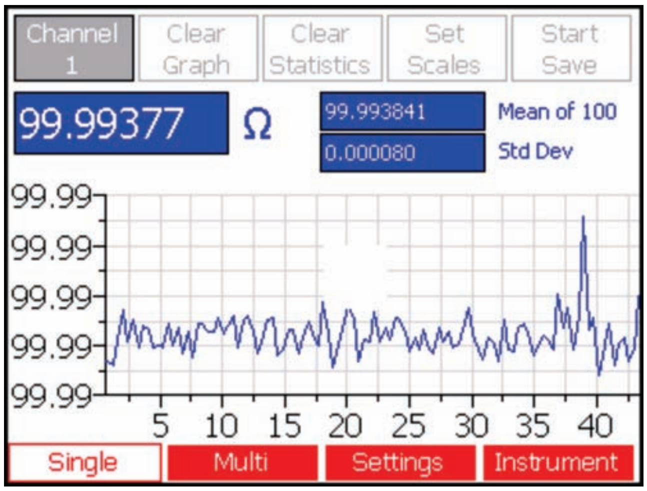
Three channels

Universal two inputs – Thermocouples, RTD's, Thermistors

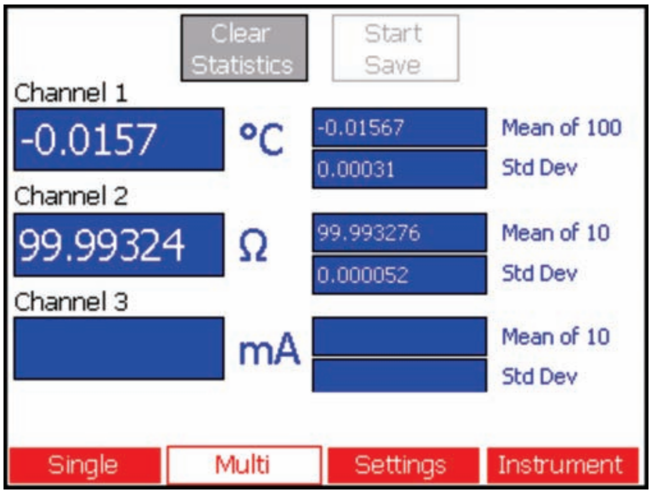
Third channel for process signals, transmitters with loop power supply on same loop

Performance : 3mK at 0^{o}C, 4mK over 1 year, Resolution of 0.0001^{o}C, 0.1mK, Thermocouples - 2µV and 4µV over 12 months, For Type K – 4µV =0.1 ^{o}C

For industrial demand, the milliK has capacity to log time stamped data for up to six months internally, add a low cost USB Memory Drive and store a lifetime of data. On the same USB you can plug a Mouse / Keyboard to ease entering probe calibration data, Set Programs etc. This has a Colour Display, toggle of display from a Choice of Strip Chart or Numeric representation, Includes simultaneous view of all three channels



Other advantages being : Isolated Inputs, High Degree of Galvanic Isolation, Sensor Inputs Isolated from current input, Avoids Problems with high voltage pick up on TC inputs, Safety compliance, Built in 24VDC PSU, Two Serial Ports - For PC connections to PC and Dry Block, Easy to program SCPI Style Interface, Controls ISOTECH Dry Blocks and Baths, USB Host, Memory Stick / Mouse / Keyboard,



Ethernet / Remote control over network

Industrial multichannel measuring requirements with high precision. – Yes, The millisKanner allows for more channel inputs through the millisKanner Channel Expander - Connect SPRT, PRT, Thermistor or Thermocouple on any channel

It is not just a scanner !! Based on Solid State Design, No mechanical relays, High Reliability, Isolated Inputs, Galvanic Isolation Between both contacts and PSU and Control Circuitry, Benefits – Better Measurements and lower noise, Intelligent Design - Automatically adapts to suit sensor types, Handles Thermal EMFs for PRT and TCs, milliK Automatically Senses new millisKanners and all are Driven from milliK, milliK does the thinking and Self configures and can support maximum of four millisKanners – thereby allowing 33 Channels in total Plus Current Input

Thus this has allowed the industry houses to have a new solution for multiple channel precision measurement, Unmatched in performance by any other datalogger or scanner.

UNIVERSAL CALIBRATION / TESTING SOLUTIONS

Till now, most of the industires are using specific equipent for specific parameter and application pertaining to temperature, pressure, process, electrical electronic requirements.

For a better useage, there is a requirement of having all these consolidated in one place. Innovative ideas have enabled this becoming a reality.

A complete calibration laboratory in one test bench – an ideal solution for the industry which can be customized for specific application.

Universal CalBench is the ultimate multifunction calibration station designed for the industry - Each bench is custom-made to meet specific user requirements. Offering versatility and precision it is ideal for laboratories and workshops in need of multi-product testing that meets the highest industry standards.

A wide range of modules can be fitted to the primary console creating a highly flexible system that is both functional and easy to use. Further expansion can be achieved by adding the secondary console, mounted under the primary.

Calibration modules cover electronic signal, temperature, loop, and pressure applications. Power supplies, DMMs, oscilloscopes and generator modules can also be fitted into the bench consoles. Functions are clearly defined on each module and a competent technician can quickly master the operation of the system. Various fittings, functions, and additional devices can be added to CalBench to create a comprehensive work environment.

This provides a single station which can cater to all industrial testing / calibration requirements for :-

Temperature Indicators

Temperature Sensors

RTD Transmitters

Timer Counters

Thermocouple Transmitters

Pressure Transducers

Frequency Meters

Decade Boxes

Pressure Transmitters

Ohmmeters

Multimeters

AC/DC Signal Sources

Signal Generators

Oscilloscopes

AC/DC Millivoltmeters

Loop Signal Indicators

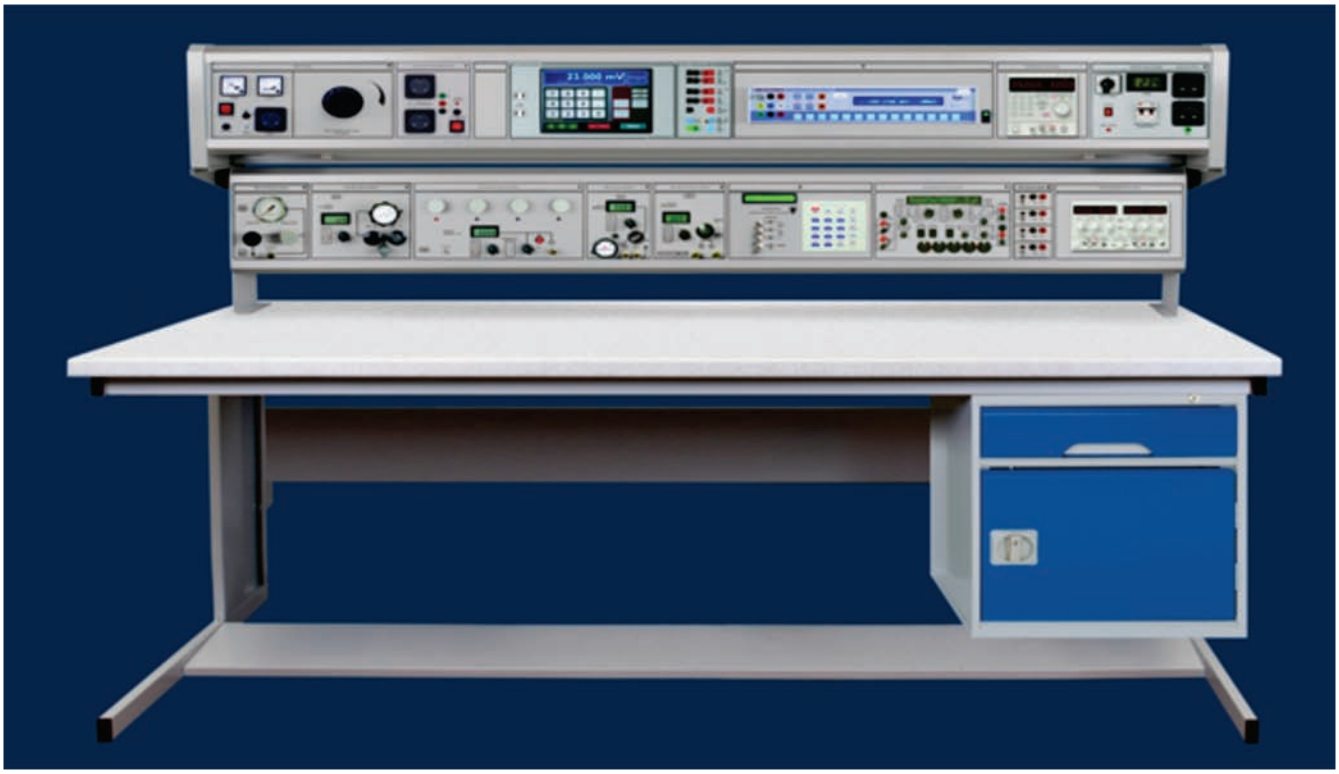
Pressure Gauges

Clamp Meters

Tachometers

Etc.

A turnkey laboratory design service for industries requiring a complete and efficient test facility is also available.



An ISO 17025 universal calibration software is designed and available. This can

- Communicate with compatible CalBench modules
- Automated planning and scheduling
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- Quickly generate procedures using templates
- 1200+ pre-written test procedures included
- Calibration due reminder system
- E-mail reminder letters and lists
- Customise reports and certificates
- Create PDF reports and certificates (PDF engine)
- Print and read bar codes
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- HART and Foundation Fieldbus communication
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- Create uncertainty tables for laboratory & site
- WebCert feature for online certificates

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ACHIEVING UNIFIED HMI THROUGH DCS INTEROPERABILITY

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ABSTRACT

Packaging concept in a coal fired power plant has many advantages; the first & foremost being that of cost. But needless to say, one of the de-merits is the plethora of control system (DCS & PLC) & consequently the variety in HMI. Uniformity of the front end to the process being controlled has always been the wish list of the end user i.e. the operator, being oblivious to the underlying dynamics of the control platform. One of the traditional & very obvious approach of achieving this is to go for a total turnkey package, with a single DCS for the main plant.

This paper presents the concept of Unified HMI through DCS inter-operability, a technology alternative to achieving the same through total turnkey packaging. In this concept, the drives of one DCS is operated by the HMI of another DCS, leading to a single unified HMI for the control room. The design considerations in evolving this concept has been described along with details of an actual implementation.

KEYWORDS

Unified HMI, Distributed Control system (DCS), OPC, Modbus, Response time, Inter- operability

1.0 INTRODUCTION:

Ever since the introduction of Distributed Control Systems (DCS), the operator interface to the process had undergone a sea change; from push button stations to CRT to latest state of the art workstations & large video screens (LVS). Today, fast navigation, trends, LVS based annunciation provide the operator all tools for effective operation.

The DCS/PLC based systems of early 90's eras were based on proprietary operating systems, both for the control system as well as for Human Machine Interface (HMI) .The communication network between the control system and HMI was also proprietary, requiring system specific interfacing hardware and software. Now with systems based on open architecture & commercial off the shelf (COTS) hardware, the capabilities of the HMI have increased many fold; so are the demands from these systems. Availability of process data from open architecture systems & the portability of the same to third party software through communication interfaces has become very common & the slogan "Field to Boardroom" has become the buzzword today. Can the advancements lead to a situation of true inter-operability in DCS? Let us examine in detail.

2.0 A TYPICAL DCS/PLC NETWORK IN A POWER PLANT

A typical DCS consists of Control system in which the interlock, protections & sequences (OLCS) & modulating controls (CLCS) are implemented and the HMI (Human Machine Interface) through which drive/sequence operations, plant monitoring, historical event & trend analysis etc. is carried out. An overview of the same is given in Figure 1.

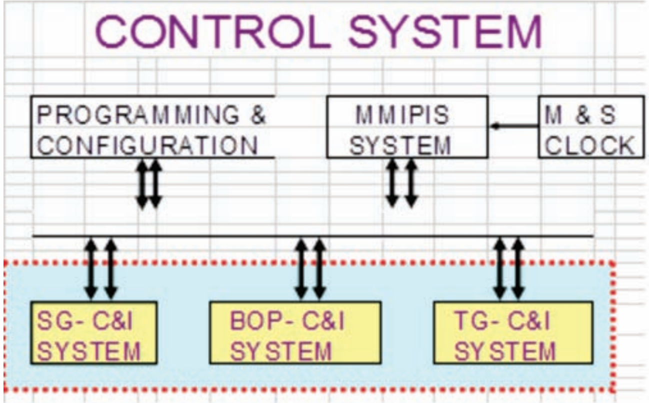

Figure 1 Typical DCS

In present day scenario, in a DCS, the HMI & the control system are tightly coupled with proprietary interfaces, with the result that HMI of one DCS cannot usually work with the control system of another DCS, unless special interfaces are developed by both the DCS suppliers.

3.0 PACKAGING CONCEPT IN POWER PLANT:

The number of contracting packages for a power plant depends on various considerations; some of these being Cost, Engineering (which includes interfacing requirements), and Vendor base.

The control system (DCS or PLC) for the equipment being supplied under a package is either a part of the package or procured separately, either in part or whole. This has led to various packaging philosophies, for main plant as detailed below:

a) Main plant turnkey where the entire main plant equipment (SG, TG and main plant auxiliaries) is procured under a single package

b) SG-TG: where SG equipment is procured under SG package and TG equipment under TG package. In this case, one DCS is there for integral controls of SG equipment in SG package, another DCS for the integral controls of TG equipment in TG package. For the balance of plant controls of main plant, a separate Station C&I package is provided.

There are other combinations also, but at present we will confine the treatment to SG-TG at b) where three different DCS are provided for main plant controls, each with its own HMI. As a result, the operator in the main plant control room has to operate the plant from three different HMIs. A typical arrangement of screens in such an arrangement is depicted in Figure

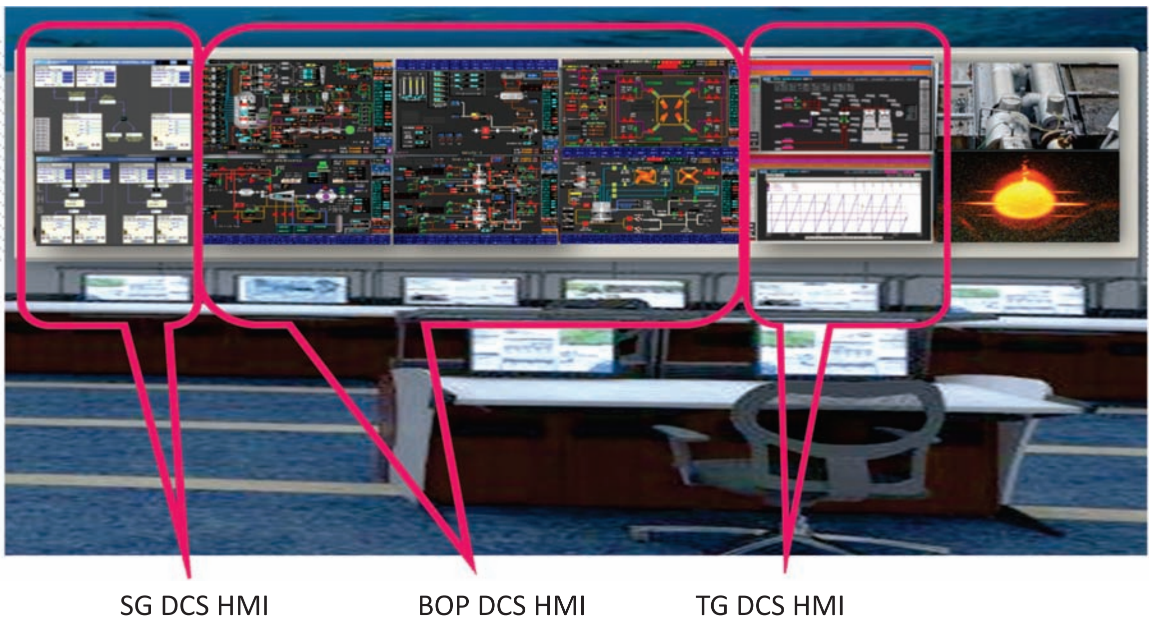

Figure 2: Operating screens in a SG TG packaging concept in a power plant

Another variant of b) is that within a package itself, there are two control systems, Eg TG package where TG integral controls are implemented in the DCS of the TG OEM & balance of plants

controls of TG package in another DCS. This further aggravates the situation leading to as many as four different HMIs in the unit control room.

4.0 NEED FOR UNIFIED HMI:

Different HMIs in the unit control room means different set of faceplates, different look of graphics, different tools & GUI for HMI functions like trend, logs, trip analysis etc, different views of alarms/ events.

This also leads to a situation where operation of any area of the main plant cannot be done from any workstation or LVS. It has to be done from the workstation/LVS earmarked for a particular area. This eventually leads to increase in number of screens & also to a certain extent, increase in number of operators.

This is tantamount to something pointed out by an Operations personnel in some meet - “A Car with multiple steering”.

Having a single HMI increases ease of operation especially during plant disturbances, thereby providing intangible benefits.

5.0 STRATEGIES FOR HMI UNIFICATION:

A) Single DCS for the main plant:

A single DCS for the entire main plant automatically ensures that the HMI also is single. This can be achieved either through a single main plant EPC package with a single DCS for entire package, or separating out the controls of the main equipment in a separate package. The latter is not generally achieved especially in case of turbine integral controls.

B) DCS Inter-Operability: The strategy here is to overcome the constraints of packaging philosophy by having a single HMI in multiple DCS situations through DCS inter-operability i.e. to have communication links between the two DCS through which the drives of one DCS is operated from the

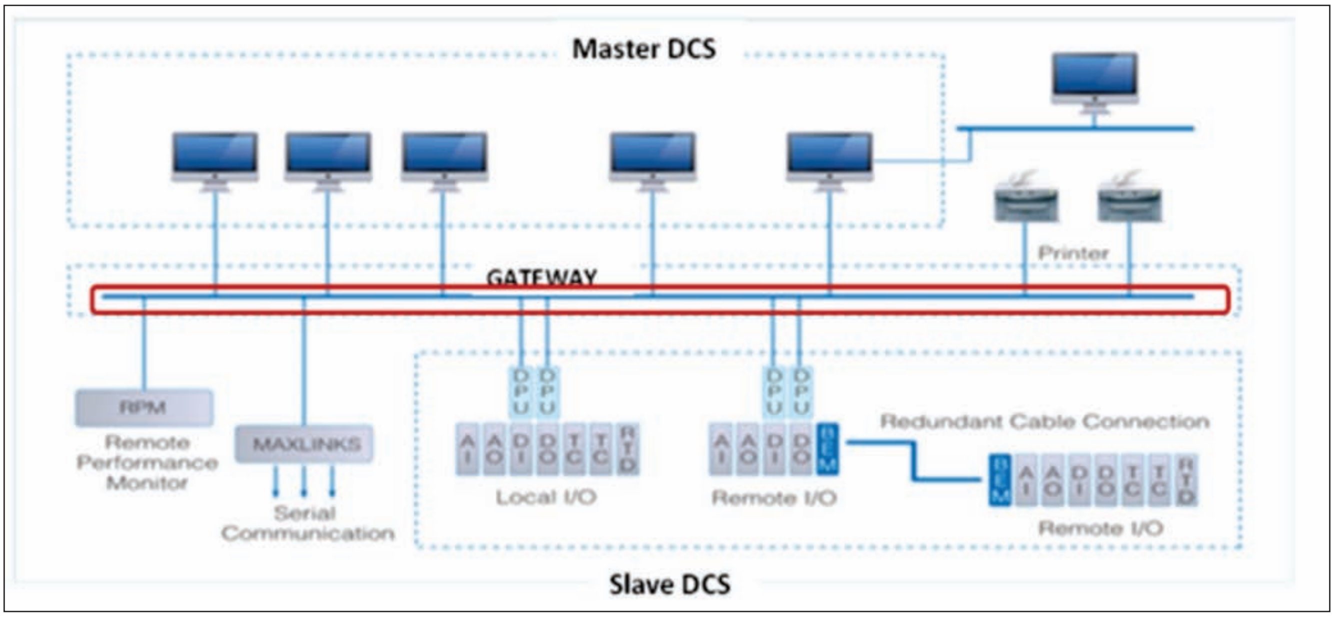

Figure 3A: Scenario A

HMI of another DCS.

6.0 DCS INTER-OPERABILITY SCENARIOS:

Considering that one DCS (Master DCS) has to operate another DCS (Slave DCS), some scenarios are described below, & depicted pictorially in Figure-3A-3D.

a) Scenario A: The control system of Slave DCS is interfaced with the HMI of Master DCS, through a gateway interface, specifically developed for the purpose. Obviously, this solution is not standard, and needs to developed for every combination of Master & Slave. Above all, it involves a great deal of effort on the part of developers of both the DCS.

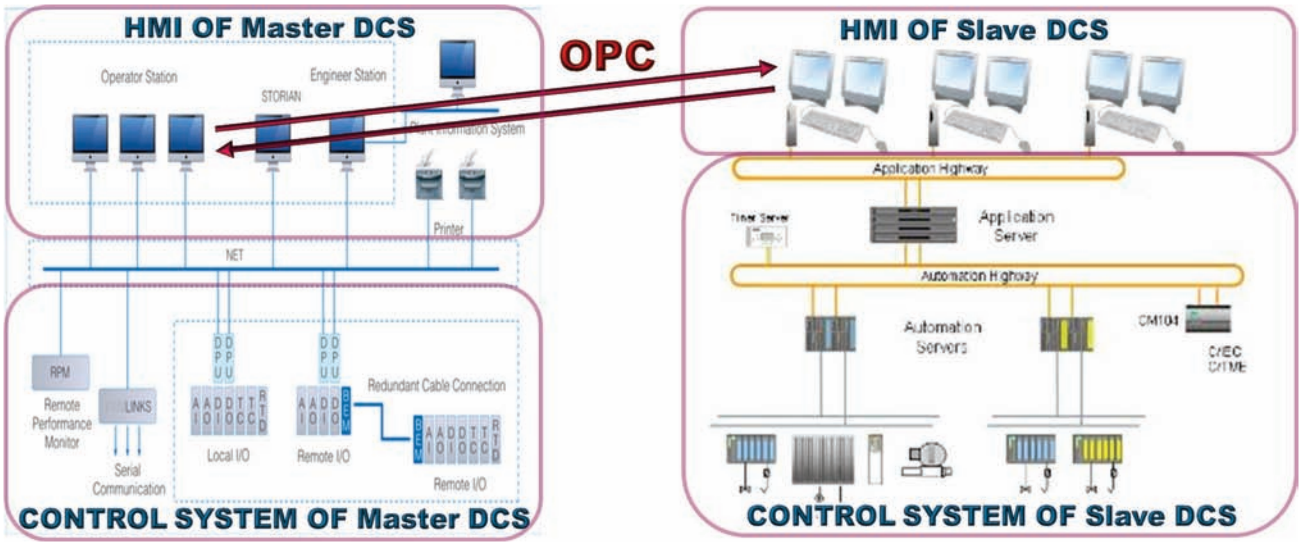

Figure 3B: Scenario B

b) Scenario B: The HMI of Slave DCS is interfaced with the HMI of Master DCS, typically through OPC, for transfer of signals including operation command & feedbacks. The HMI of Master DCS apart from having the database of drives of Master DCS, has also the database of drives of Slave DCS.

c) Scenario C: The control system of Slave DCS is interfaced with the control system of Master DCS for transfer of signals including operation command & feedbacks through typically MODBUS TCP/IP protocol.

Scenario A is always very specific for the combination of Master & Slave DCS & also involves huge efforts for development of a proprietary interface between the DCS. Hence, this option was not further explored.

Scenario B can be used if the OPC implementation can guarantee a deterministic response time or the timings are not very demanding eg for supervisory commands, say initiation of drive command sequences. For direct drive operation, especially for critical drives, where latency cannot be tolerated, this will not be a right solution.

Scenario C uses typically MODBUS TCP/IP protocol to transfer signals between Master DCS & Slave DCS. The entire signals (analog &

binary) & the drive signals of Slave DCS are mapped in the Master DCS. The sizing of database of Master DCS takes into account this aspect. Due to its deterministic timings, real time command response times can be achieved in this scenario & hence

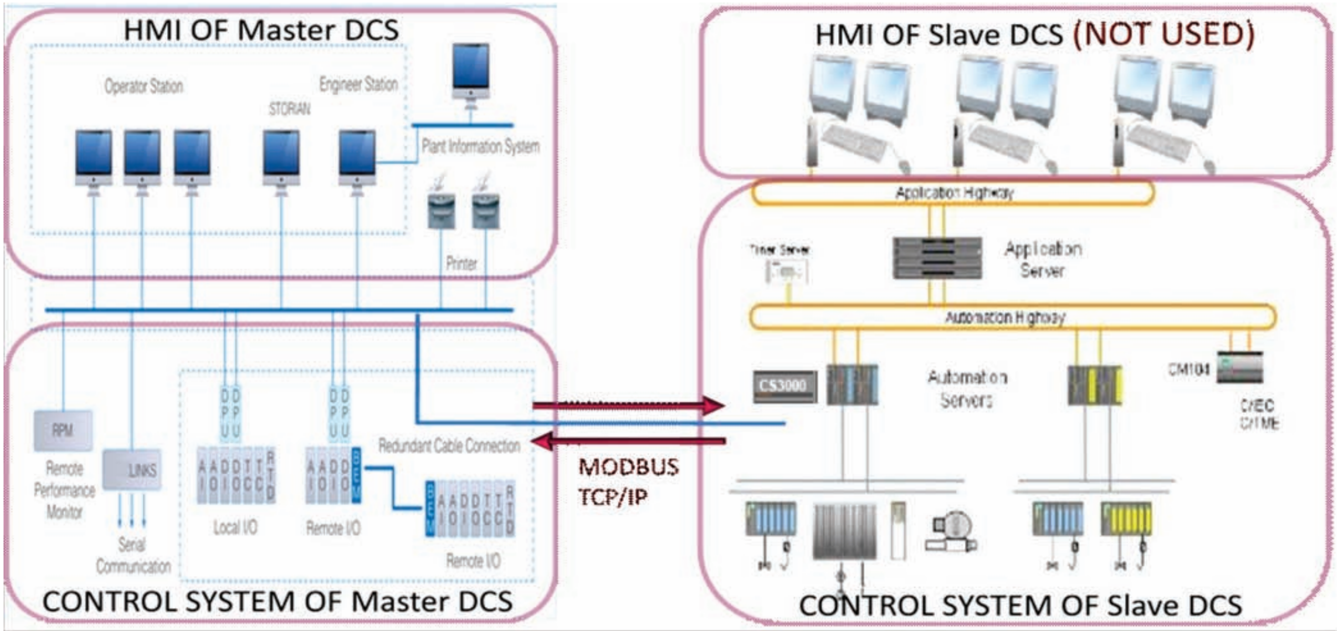

Figure 3C: Scenario C

quite suited for the power plant controls. Another advantage with this scenario is for extremely critical controls like Turbine Governing, the signal exchange for command & feedback between Master DCS & Slave DCS can be implemented using hardwiring ; the 'Good Old' 4-20 mA signals used typically for sending commands from Feed water controls to TDBFP speed controls or from Combustion controls to Feeder controls.

All the above merits with Scenario C makes the realization of Unified HMI pragmatic and do-able. In the actual implementation also, this scheme is used.

Another variant is the case of Scenario D where both Master & Slave DCS are operated from a separate independent HMI under a HMI package. In this case, all the drives of both DCS have to be operated from a HMI different from its native HMI. In Scenario C, at least the drives of Master DCS, the operation is from

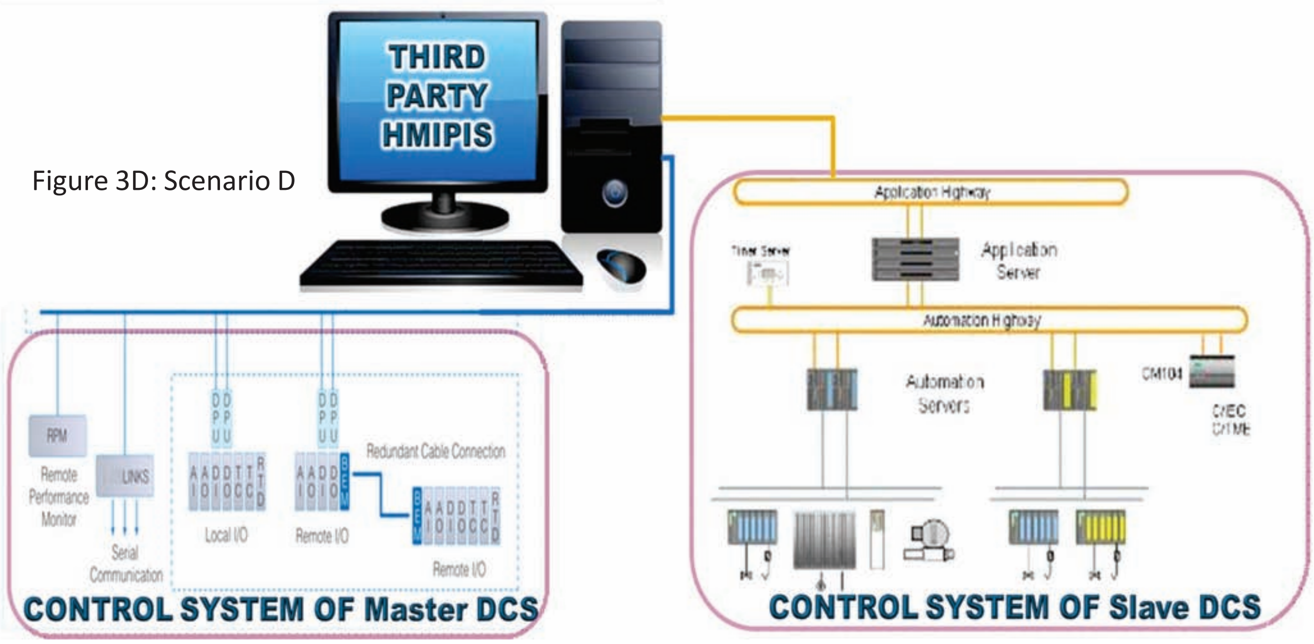

Figure 3D: Scenario D

its native HMI, which is the preferred scenario. Due to this, scenario D is not further explored.

7.0 INTRA PACKAGE UNIFIED HMI:

As pointed out at 3.0 above, sometimes, TG package within itself has two DCS, one for TG integral controls & other for balance controls, leading to a situation of two different HMI for operating the drives of TG package in the control room. While a single DCS could not be specified, requirement of a single unified HMI was specified in such situations in the tender specifications of Mauda-II TG package. i.e. if two DCS are supplied by the TG package vendor, HMI shall be a single unified system. This was a triggering point for the implementation of Unified HMI in NTPC.

8.0 INTER PACKAGE UNIFIED HMI:

Having the scheme of Unified HMI within package (Intra package) leaves most of the design aspects to the package vendor and are finalized during the detailed engineering stage. This provides a lot of flexibility to the vendor in these aspects.

However, specifying such a concept for Inter package is quite challenging as many of the design aspects has to be specified outright in the tender stage. The first & foremost criteria is who will become the Master DCS. In the packaging system as prevalent today in NTPC, there are three packages, SG EPC, TG EPC & BOP EPC (for off sites). Hence, the choice of master for main plant HMI has to be between DCS of SG EPC & TG EPC. The controls being envisaged in these packages are indicated in the following table.

Sl. No.	SG EPC Controls	TG EPC Controls
1.	SG Integral	TG Integral
2.	SG BOP	TG BOP
2.	SG Standalone (Compressor, CW/CT, ESP AC)	TG Standalone (CPU Regeneration, CPU Vessel, Main Plant AC)
3.	AHP	
4.	FOPH	
5.	AUX BOILER	

The considerations which typically go into the selection of the master DCS are:

a) Coverage of drives: One criteria can be that maximum drives in the main plant should be operated from its native HMI, in which case, the DCS which has substantially more drives becomes the master.

b) Coverage of controls: Another criteria for the selection of master is the DCS where most of the important control loops of the generating unit (such as Combustion controls, steam temperature controls, feed water controls) are implemented.

Applying the above considerations to the main plant of a coal fired thermal power plant makes SG DCS as an obvious choice for the Master. This philosophy has been specified in EPC projects starting from Telengana onwards.

9.0 SOME DESIGN ASPECTS OF THE ACTUAL IMPLEMENTATION:

In Mauda-II TG package, BHEL was the TG package vendor with steam turbine from Siemens, Germany. Here, there were two DCS, SPPA T3000 of Siemens for the TG integral controls, namely Turbine Protection system, Turbine Governing controls, ATRS (Automatic Turbine Run up system), ATT (Automatic Turbine Testing), TSE (Turbine Stress Evaluator) and maxDNA of BHEL, EDN for the balance controls, namely HP/LP Bypass, TDBFP DT binary controls, TDBFP Governing, COLTS (Condensate On line Tube cleaning system), SGC Evacuation and self-cleaning strainers. Due to the specification requirement of Unified HMI, a scheme for operation of SPPA T3000 drives from the HMI of maxDNA was conceptualized by BHEL, EDN & finalized with NTPC after several rounds of discussions. An overview sketch of the same is given below in Figure 4.

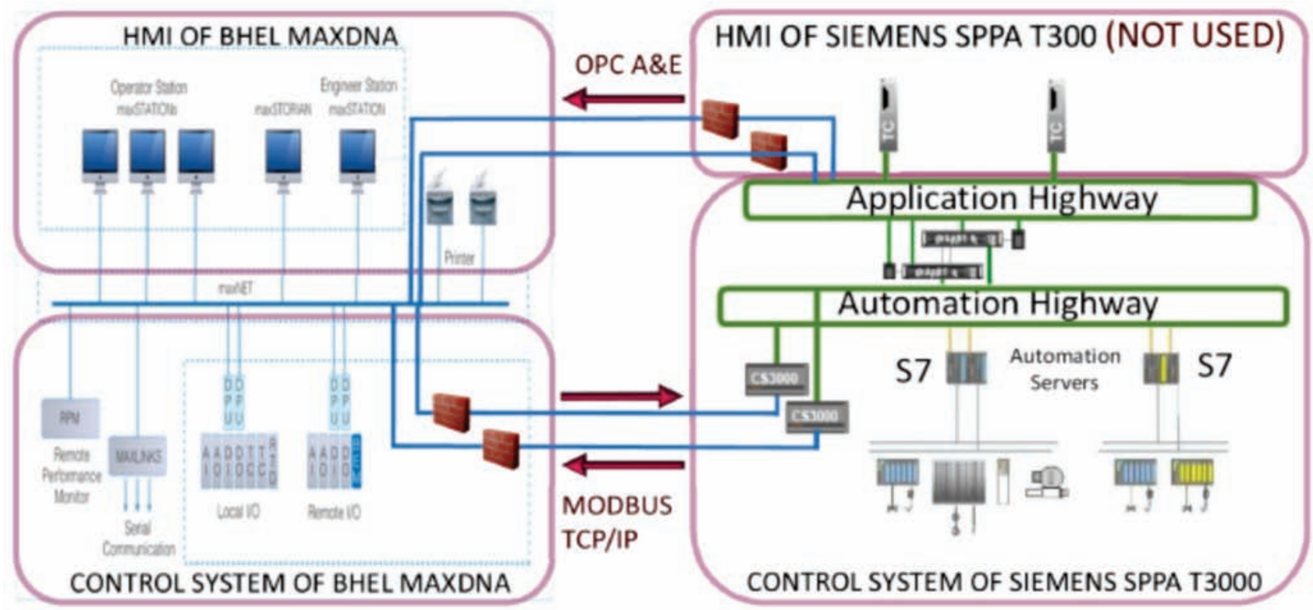

Figure 4: Mauda-II actual implementation

The salient features of this scheme are detailed below:

a) MODBUS modules were included in one to one connectivity between Siemens system & BHEL system. All signals of SPPA T3000 system were transferred to maxDNA using these links.

b) All signals were distributed between these MODBUS links.

c) The cycle time for all these links were set depending on the type of signals.

d) The MODBUS links were made redundant with bump less switchover between the same.

e) Due to the requirement of time stamping, alarms were transferred over OPC A&E from SPPA T3000 HMI to maxDNA HMI. i.e. an additional HMI OPC link was provided for alarms.

f) The native HMIs are kept in Programmer room and Unified HMI in CCR.

The scheme was tested extensively at the works of Siemens, Germany where a prototype of maxDNA system with the required interfaces, operator stations, historians were taken from BHEL,EDN Bangalore. The critical part of the testing was the achieved command response times, which were very close to the times achieved with the native HMI. Another critical area was the changeover between the MODBUS links, since the resiliency as provided in the native HMI had to be maintained in the Unified HMI.

Last but not the least, it was ensured that commissioning of the TG integral controls takes place from the Unified HMI right from the initial commissioning stage. The habits formed during the initial commissioning remain throughout the plant cycle & hence this aspect is critical to success of the scheme. It may not be out of place to mention here that in one of the power plants, unified HMI was conceived & implemented, but both the HMIs were placed on the Unit Control desk, & due to this, operators were using only the native HMI, defeating the purpose of the Unified HMI concept.

10.0 CONCLUSION:

Technology has to be harnessed to overcome the barriers of packaging system and to create a seamless operator interface in the control room, with the underlying dynamics & jugglery being oblivious to the operation personnel. The importance of prudent & pragmatic engineering in the finalization of the Unified HMI scheme for any DCS combination cannot be undermined. The cycle times of the MODBUS links, the quantity of MODBUS links & signal distribution among these links, the redundancy & the resiliency of the MODBUS links, mapping of the signals & the mimic engineering has to be done meticulously. This leads to huge efforts on the part of the DCS vendors as well as the customer's engineers, but the efforts are worth the result.

Depending upon the feedback of implementation, this scheme is likely to undergo improvements & eventually, the day will not be far when the entire controls of the TG package will be executed in SG package, barring the core controls of TG, namely turbine governing, turbine protection and turbine stress control.

11.0 ACKNOWLEDGEMENTS:

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R. Sarangapani is an Additional General Manager in Project Engineering-C&I Dept of NTPC Ltd. in its engineering office, based in Noida. He has been involved in the engineering of many thermal power plants as well as factory testing of many DCS systems/simulators.

Mr. Sarangapani has 27 years' experience in power plant C&I engineering. His exclusive focus areas are HMI engineering, Third party interfacing & OPC, display systems, control system networking, network security, closed loop control, Power Plant Performance Optimization, Simulator, and Standardization in engineering processes.

Mr. Sarangapani has been actively involved in the DCS network security architecture of NTPC and the development of network security policies & procedures. He has also been associated in the commissioning of C&I systems at site.

He has authored papers, for national & international conferences including the International Society of Automation(ISA) POWID division, for which he had coined the theme "Empowering Power with Automation" for its first conference of its Delhi Division in 2009.

He is currently involved in the preparation of the Indian manual for Cyber Security in Power Systems.

Mr. Sarangapani has done B.E in Control & Instrumentation from Thapar Institute of Engg. & Technology, Patiala & M.Tech in Computer Science from IETE.

Some Nath Kundu is an Senior Manager in Project Engineering-C&I Dept. of

Evolution of Industry 4.0

Digitalisation continues its forward march and is changing business across all industries.

There is good reason why trade shows worldwide are making developments in Industry 4.0 a central topic. The foundation for digitalisation is secure and flexible IT infrastructures, which are imperative for configuring highly automated production processes. According to BITKOM, Germany's Federal Association for Information Technology, Telecommunications and New Media, and a forecast by the consulting firm Experton Group, German companies will invest about 10.9 billion euros in Industry 4.0 IT and control solutions by the year 2020. In 2015 alone, investments of approximately 650 million euros are planned, about 45 percent more than in 2014. Yet some are sceptical about the future success of Industry 4.0 approaches, or at least see these being realised over a much longer time period. But the critics shouldn't spend too much time on this issue, because Industry 4.0 will change many production processes. Small and medium-sized enterprises in particular are lagging behind in the digital revolution. Federation of Germany Industries (BDI) President Ulrich Grillo has stated that this topic, new for many companies, must be more widely discussed. Clearly the changes that Industry 4.0 entails are unsettling for Germany's small and medium sized businesses, many of which (still) feel secure in their traditional niches. Industry 4.0 is for most a buzzword associated with fears and, even more so, resistance. Yet Industry 4.0's cost-cutting effects in production processes can already be assessed.

According to a study carried out by the management consulting firm Boston Consulting Group for Germany's Manager Magazine, the potential of Industry 4.0 is substantial: manufacturing industries could achieve productivity gains worth up to 150 billion euros within ten years. National economies will also benefit: gross domestic product could grow an additional 1 per cent per annum on account of Industry 4.0. This development calls for nothing less than making traditionally rigid manufacturing systems, geared to just a single function, more flexible through the assistance of digital communication. The same holds true for areas such as work processes, human resources planning, parts management and logistics, to name just a few.

An IP address in every device

"The digitalised production environment of Industry 4.0 places very new challenging demands on data security, processes and IT services," says Bernd Hanstein, Vice President Product Management IT at Rittal. IT infrastructure is assigned a key role as enabling technology in this Process; Industry 4.0 is inconceivable without stable and scalable IT infrastructure. Christian Illek, Head of Microsoft Germany, finds that many small and medium-sized businesses believe the topic is one "for the generation after the next one." Manager Magazin recently wrote that this fallacy has far-reaching consequences. The magazine reports that in California, the epicentre of the digital economy, preparations have long been underway for "tectonic shifts in wealth." Back in 2011, venture capitalist Marc Andreessen observed that software is eating the world. In fact, one industry after another has been digitally dismembered: music, film, media, trade – and now it's manufacturing's turn.

In oversimplified terms, one could say that Industry

4.0 entails providing an IP address for each ever-so-small element in a production line, right down to a 24-volt power supply on a top hat rail. This future is no fantasy: in Germany, 15 per cent of all small and medium-sized manufacturing companies are already using decentralised,

networked, self-regulating production processes, according to a recent survey conducted by Pierre Audoin Consultants, an independent market research and consulting firm, on behalf of Freudenberg IT, an IT solutions provider. Early adopters in Germany can especially be found among automobile industry suppliers with company sizes of 500 employees and more.

Sound foundation essential:

Industry 4.0 Infrastructure includes active components such as switches and the complete portfolio of networking elements: housings and enclosure systems as well as the necessary cooling and climate-control equipment along with their monitoring systems. The data and connections within this infrastructure must be as protected from

hot and dusty production environments as the information in the 19-inch enclosures in a data centre. It is therefore essential to include even small enclosures for production facilities within overall protection schemes. Warmth must be absorbed at the source, removed by means of a cooling medium and then dissipated into the environment at another location. Until now, companies have for the most part oriented their IT strategies towards maximum uptimes. Industry 4.0 will inevitably prise open this perspective. As the results of a study by market research company IDC on behalf of Rittal show, changes due to Industry 4.0 will occur mainly in individual data centres, in large part because of the networked sensors and actuators within every machine. At the same time, the networking of these parts is not a one-way street for security issues alone. Extreme amounts of damage could occur if control of these components ends up in the wrong hands.

How great the need for action is in this respect was shown in a study by the market research and consulting firm Techconsult, based in Kassel, Germany. According to this study, only a good quarter of small and medium-sized businesses already have their own independent security strategy. About half of them deal with IT security merely within the scope of a general IT strategy, and one-fifth of companies are still in the process of developing an IT security strategy. The actions required move well beyond typical IT security measures such as firewalls; for networked components in a production environment, aside from monitoring with regard to environmental parameters such as excessively high temperatures and humidity, they must also be protected against unauthorised access. Intelligent control components in housings and enclosures, such as the Rittal Computer Multi Control (CMC) III, can undertake these tasks and provide additional information from the production level to a central authority. The data collected by Industry 4.0 components can then be saved and processed. Combined with information from suppliers and other company data, the services of a data centre therefore evolve into the linchpin of the company.

Note : Extract from “betop” magazine of the Friedhelm Loh Group, Germany published in Issue 01/2015

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MASS SPECTROSCOPY FOR PROCESS GAS ANALYSIS

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ABSRACT

The use of quadrupole mass spectrometry (QMS) in process analysis of industrial gases continues to increase globally. Speed of analysis, dynamic range, multiple constituents, and the ability analyzer multiple streams of different compositions result in signification economic benefits. In this paper the use of QMS in industrial applications will be discussed.

KEY WORDS

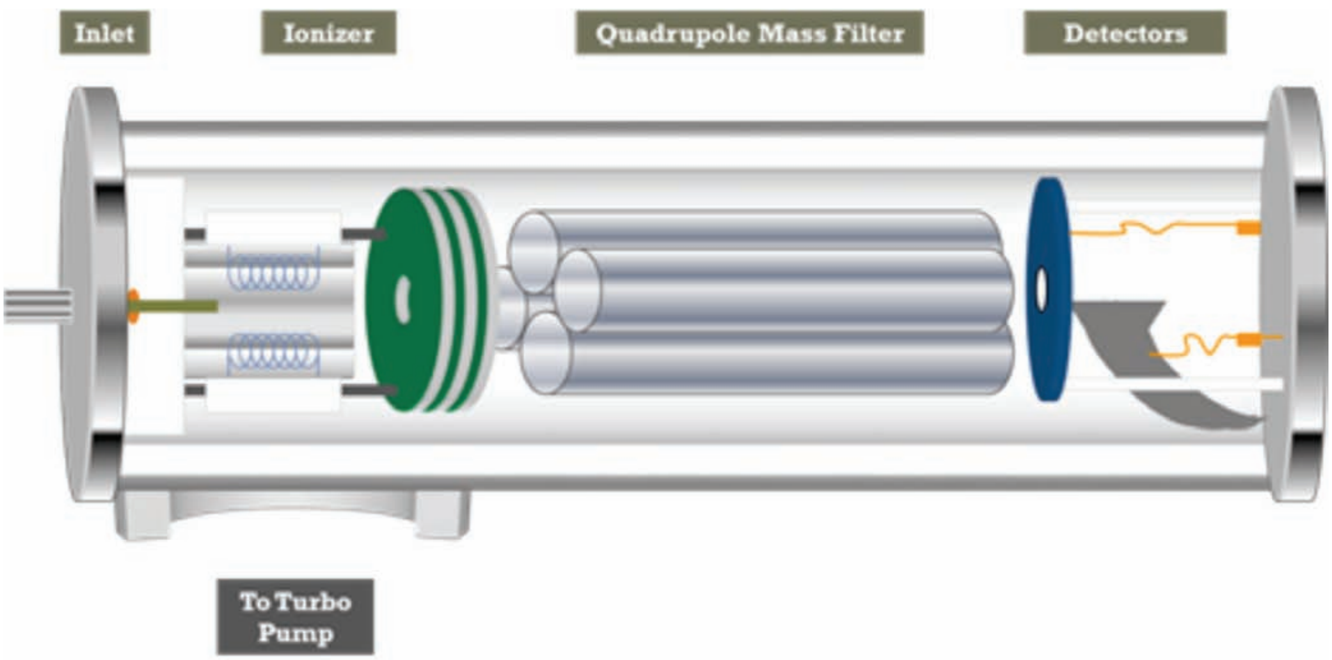
Mass Spectroscopy (MS), Quadrupole Mass Spectrometry (QMS), Process Gas Analyzers, Process Analyzer, Process Gas Analysis

INTRODUCTION

The MAX300-IG process Mass Spectrometer works with a chamber under vacuum where a constant flow of sample gas enters the analyzers. The sample gas is ionized by a beam of electrons in the vacuum chamber. Charged ions are scanned electronically to produce a set of peaks specific to the composition of the ionized gas. All gas samples and samples that can be vaporized can be analyzed with a mass spectrometer.

A process mass spectrometer can be divided into(1) Inlet, (2) Ionizer, (3) Mass Filter, (4) Detector and (5) Data Analysis

A sample selector valve is used to direct process samples, calibration or validation samples to the analyzer inlet. The typical analyzer direct inlet is fused silica with a 30 micron bore to take advantage of the pressure differential between the process



sample and the vacuum chamber. Sample is continuously supplied to the chamber at the rate of 10 microliters/minute.

AnYttrium filament is heated to emit electrons that impact and ionize the sample gas. Electron Impact ionization is highly repeatable and used with industrial application to produce positively charge ions. The set of 3 lenses with negatively charges are used to focusing ions into mass filter.

A set of four 19mm quadrupole rods is used as a mass filter to separate and focus ions one at a time onto the detectors. A faraday detectors plate allows convert ions strikes into electrical current which is directly proportional to constituent concentration. A faraday detector has a range to 10ppm, while an electron multiple extends the range to 10 ppb. If a membrane is used in combination with the inlet as a “pre-concentrator” single digit ppt measurements are possible for some compounds with high permeability through the membrane.

Questor5 software is used a Data System that controls data acquit ion, Signal processing, display, quantitative analysis and transmission of results to the DCS and maintenance computers.

TYPICAL APPLICATIONS

Approximately, 75% of all process application are for gas analysis. Process mass spectrometers are used in a wide variety of application when one or more of the following are important: Speed of analysis, dynamic range, multiple constituents, and the ability analyzer multiple streams

The MAX300-IG is widely used in environmental application because of its speed of analysis allows it to analyzer up to 160 points into a single analyzer, limits-of-detection in ppb/ppt range and dynamic range for the components measured. Application for worker exposure, ambient air limits and flare concentrations are the common application.

For refinery flare application the MAX300-IG is measuring all hydrocarbons present and all reducing sulfurs present during the normal operation of the refinery. The system then reports hydrocarbons and sulfur spices for process optimization. Plus reports Hydrogen Sulfide (H2S), Total Reducing Sulfurs (TRS) and BTU for environmental reporting.

For closed loop process control application like ammoniaand methanol production multiple constituents (6-8) are measured at multiple process points (6-12) in a 2-3 minute cycle. The real time gas analysis allows for process optimization and substantial energy savings.

To measure the ethylene cracker effluent 2-4 process gas chromatograph are used per furnace. With 12 to 16 furnaces per ethylene cracker a large number of process gas chromatograph are required. A single MAX300-IG can replace all the gas chromatograph, while redundant MAX300-IG offer an economical operational advantage.

In process reactors input and reactor output control allows for safe operation, control of product yields, and extension of the catalyst life. The MAX300-IG is used for Ethylene Oxide, gas phase polymer and Propane Dehydrogenatorreactors.

In the production of fuels products like Hydrogen, Natural Gas Analysis, Synthesis Gas, and fuel gas the MAX300-IG is used to measure all the hydrocarbons presented and to calculate the BTU value using the ASTM equation with High Heating Values (HHV). The speed of analysis is important to calculate BTU for the addition of methane or for purity testing.

Fermentation is used in the production of pharmaceuticals, bioreactors and alternative fuels. There are typically multiple reactors requiring head space analysis to monitor feed gases, biomass health and conversion to products. The speed of analysis allows for a single mass spectrometer to measure multiple reactors and replace all other analyzers.

Dryer optimization is a crucial measurement in industries like pharmaceutical, food, and polymers where residual solvents are a product quality and safety issue. Dryers are used in continuous and batch production processes with the MAX-300-IG interface to either process.

There are many other application were the mass spectrometer is used for real-time gas analysis taking advantage of its speed of analysis, abilities to measure multiple constituent, dynamic range of the constitute measurement or the ability to analyzer multiple streams of different composition.

CALIBRATION AND VALIDATION

Analyzer calibration is accomplished during commissioning using external binary mixtures and a sensitivity blend in gas bottles. Each calibration step requires <500 atm cc of gas, so that smallest gas bottle will allow for biweekly calibration for 3+ years.

Automated calibration checks are typically done every 1 to 6 months depending on the process, customer requirement or third party requirements. Calibration is required any time instrument does not accurately validate, following maintenance that involves venting the vacuum chamber.

Automated Validation can be accomplished daily, weekly or monthly depending on company policy or local regulation. Each validation requires <500 atm cc of gas so that the small gas bottle will allow for biweekly validation for 3+ years.

ANALYZER MAINTENANCE

The mass spectrometer has better than 99% uptime during normal operation and has scheduled maintenance intervals annually.

At six months the manufacturer of the roughing pumps recommend an oil changed. This requires cooling the system down to replace the oil. During this 6-8 hour maintenance system calibration is checked and updated if required.

During the annual maintenance the system is shut down for 24 to 30 hours to replace the rotary pump oil and valve seats. The vacuum chamber is opened to replace the ionizers and clean any residue on the quadrupoles. The system is started up in 6-8 hours and allowed to restore vacuum cleanliness overnight. The next morning the system calibration is checked and updated as required.

The other maintenance item is the turbo pump, which requires the oil wick to be replaced every 4 years during an annual maintenance cycle.

CONCLUSIONS

The application of mass spectrometry for real-time gas analysis is increasing taking advantage of its speed of analysis, abilities to measure multiple constituent, dynamic range of the constitute measurement or the ability to analyzer multiple streams of different composition.

Multiple components, stream switching and low maintenance drive the economic justifications, while speed of analysis or dynamic range are usually important for process control applications.

BIOGRAPHIES

Frank DeThomas is currently Vice President of Sales and Technical Support for Extrel CMS LLC.

He received his BS degree from State University of New York in 1981 in Chemistry and his Ph.D. form the University of Delaware in 1986 in Analytical Chemistry with a specialization in spectroscopy techniques.

After graduation he has worked for a number of laboratory and process analytical instrument companies holding senior position is product development, marketing, sales and as managing director. He has presented at numerous technical meets globally, is the author of several patents and technical publications.

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