Configuration Example (Large Rotating Machinery)

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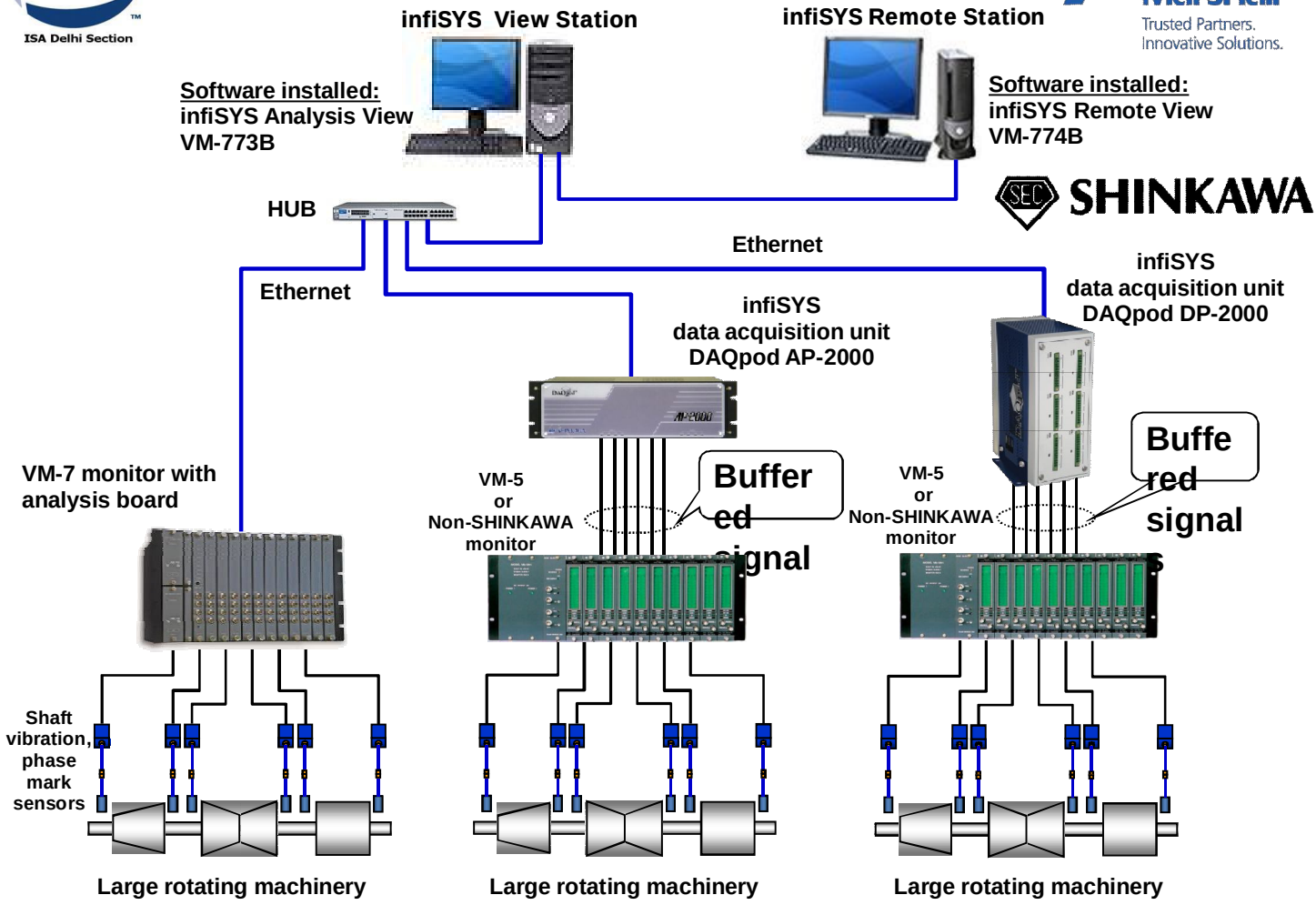
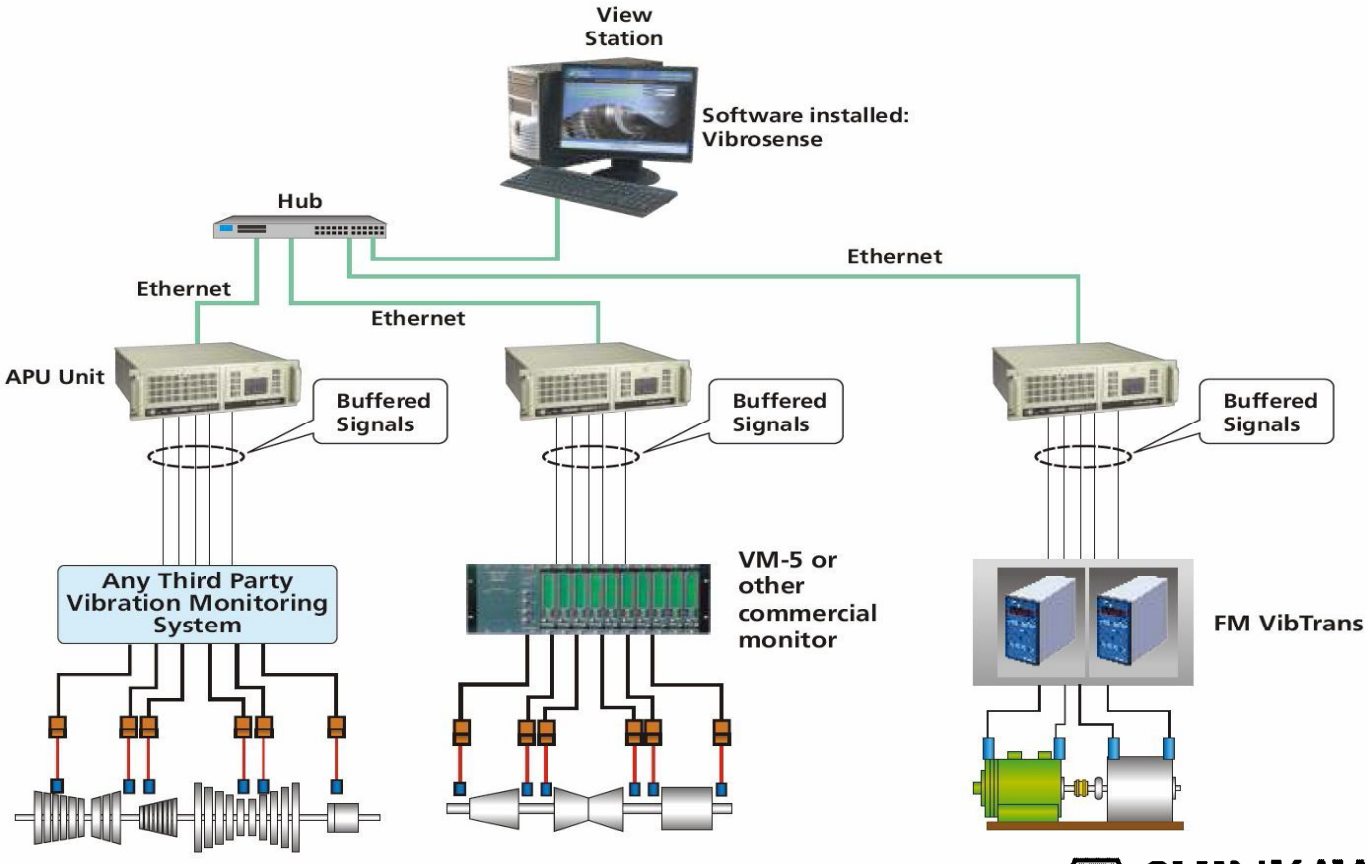
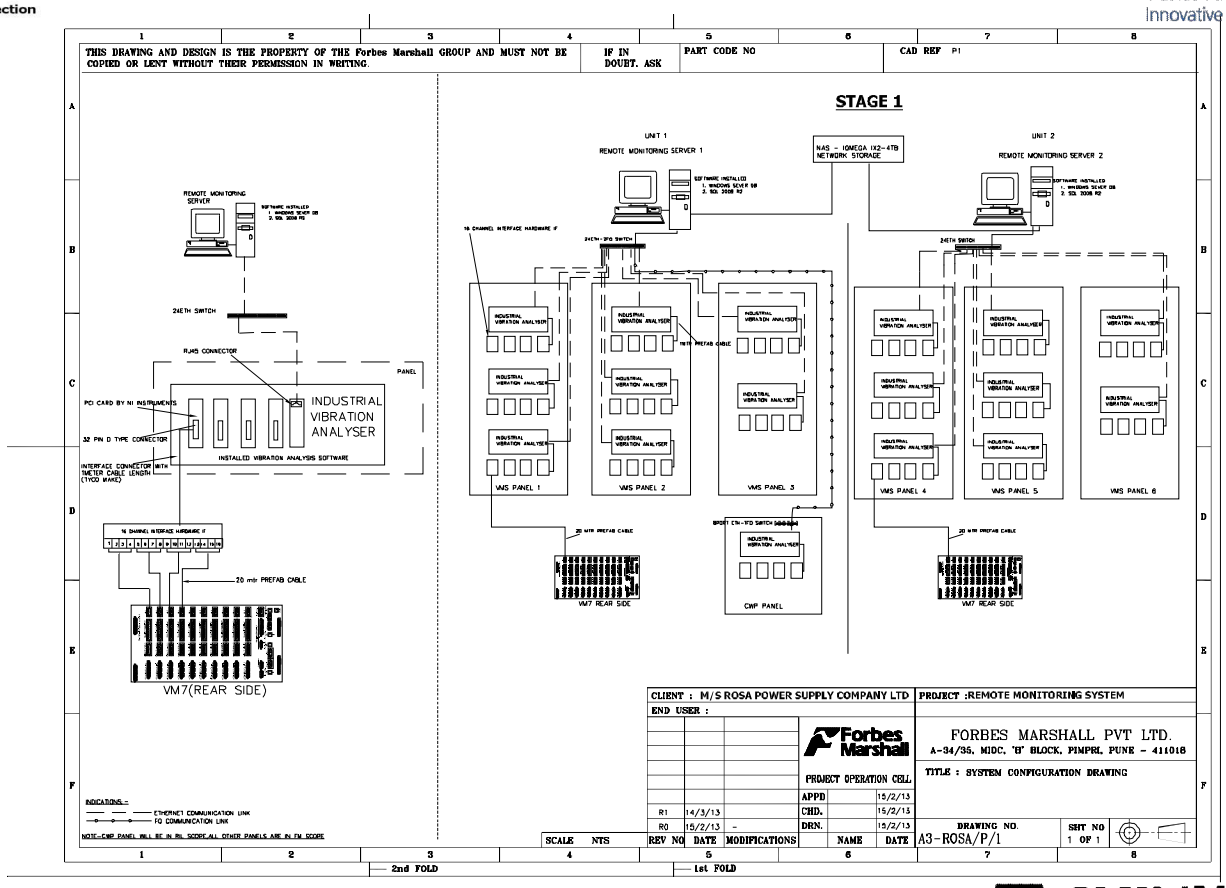


Remote Vibration System architecture



Reliance Rosa Lay Out for Remote Vibration Monitoring



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Future in On Line VMS System

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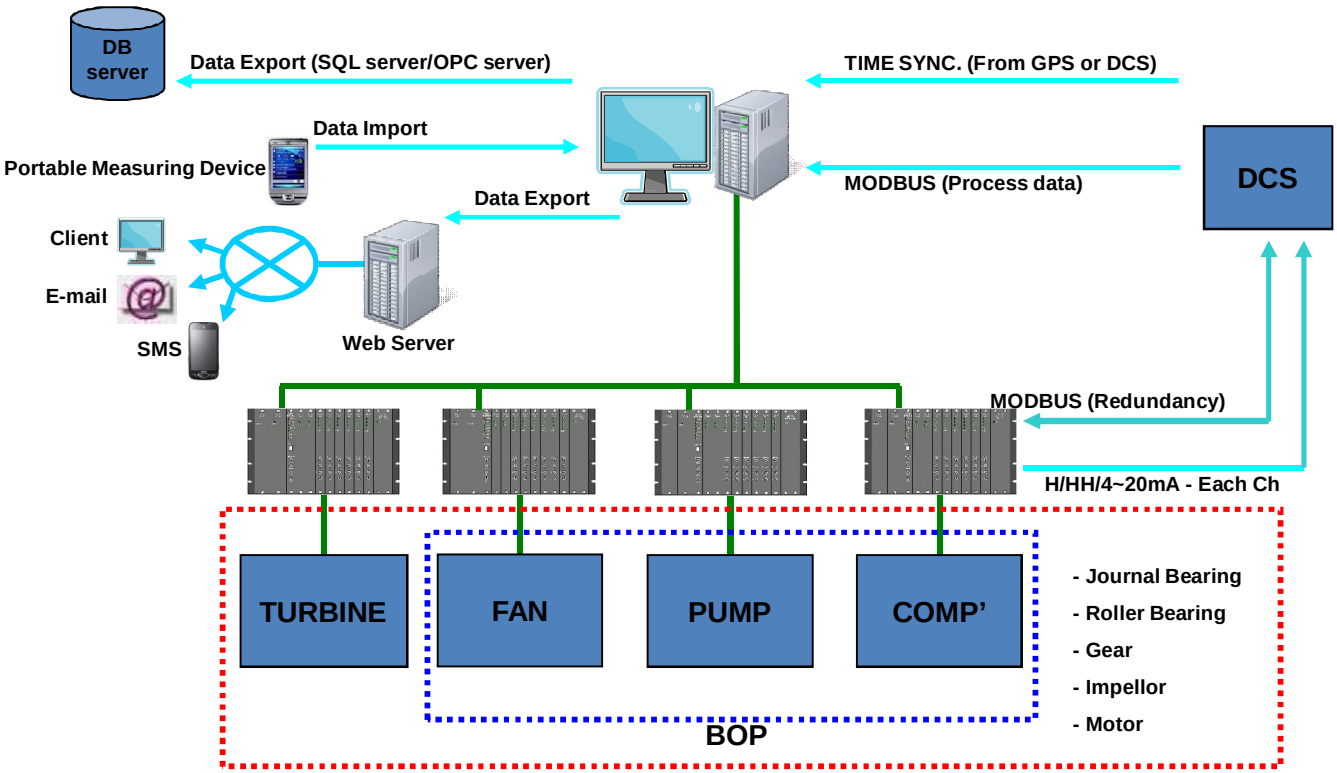
Future of On Line Vibration Monitoring System – Plant Wise Integrated System



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Portable Vibration Analysis System

Kenjin

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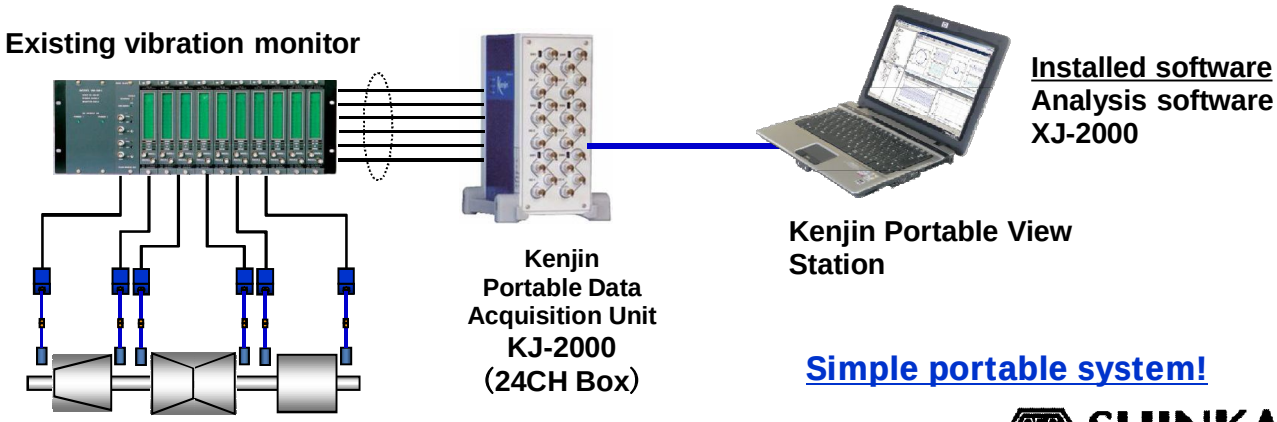
1) Easy hookup, on site analysis for rotating machinery unprotected with vibration analysis system.
2) Can be used for vibration analysis when failure occurred and/or transient data acquisition during startup and shutdown.
3) Connectable to any make monitors.



Simple portable system!

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Portable Vibration Analysis System

Kenjin

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Literally portable

- **Lightweight , compact, easy to carry**
- **Instant setup and analysis**

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Generator End Winding Vibration Monitoring System

- **It is important to have generator end winding vibration monitoring to save accidental conditions and to avoid shut down. It is done by two method :**
  - **A. Accelerometer with Charge Amplifier & Monitoring Unit.**
  - **B. Fiber Optic Vibration Sensor with Monitoring Unit.**

Turbine Blade Monitoring

- It is seen that LP Bade detoriation will reduce overall efficiency of power generation by 10%. Therefore it is focused to have solution to monitor Turbine Blade Vibration/ Detoriation on line by Two Methods:
  - Intrusion Methods
  - Non Intrusion Methods.

- With this monitoring & Right time actions will prevent the damages and help to improve efficiencies.

Conclusion

- Power Plant Owner and Consultant needs to make plant wide integrated specifications to avoid mupltiple variety system coming in the plants to reduce spare and maintenance cost. Sensor must be API670.
- Vibration Analysis & Diagnosis System is very important but need to use to get benefits.
- Remote Vibration Monitoring System is the future needs in plants.
- End Winding VMS, Turbine Blade Monitoring & Wireless Less System for non critical machine will be seen more in future.

Thank You

IV & V Process for Pre Developed Computer Based Digital I & C Systems (PDS) in NPCIL

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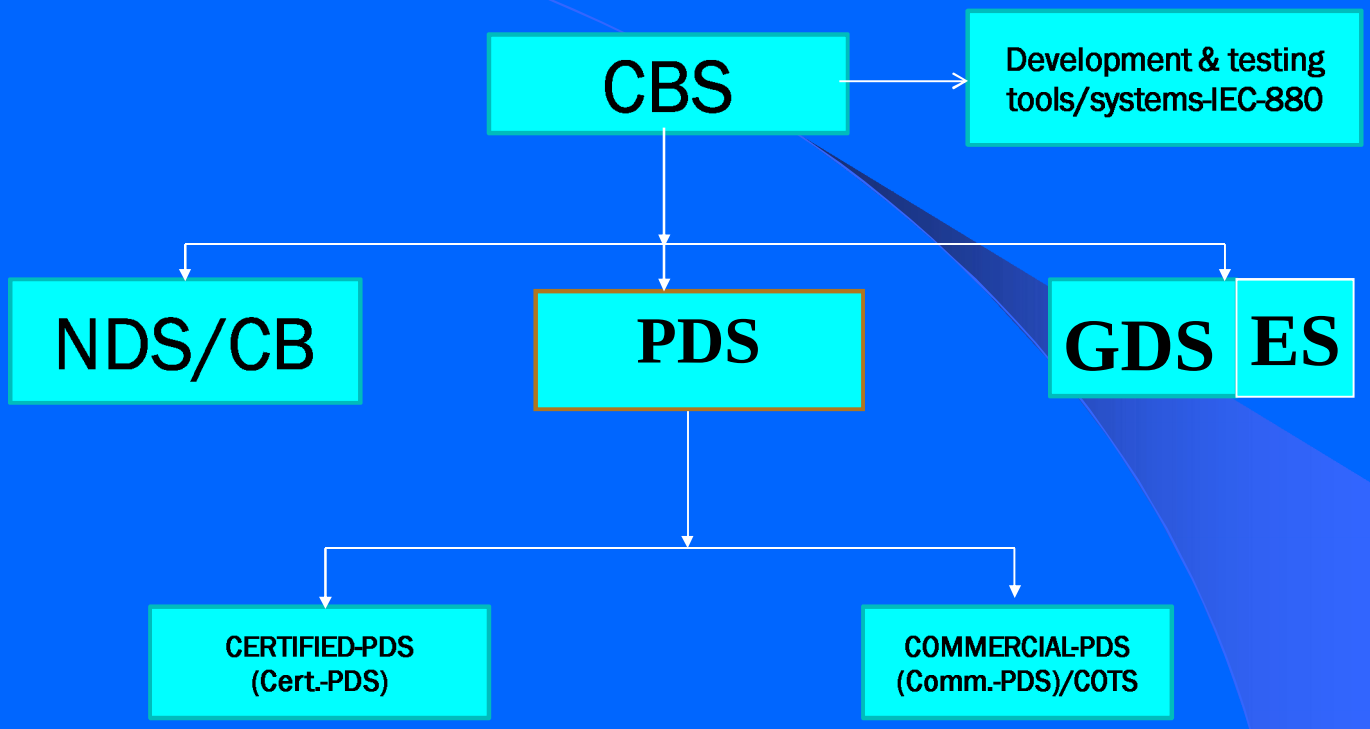
Scope

- What is CBS ? What are categories of CBS
- What is Software Quality Assurance ?
- What is IV&V Process?
- Why IV&V Process
- How to perform the IV&V Process for PDS ?
- What are the challenges during IV&V Process of PDS
- Conclusion

What is Computer Based System (CBS) in I & C system?

- **Any system or part of the system which deploys a microprocessor/microcontroller/controller for executing its intended/designed functions like control, protection or monitoring as per the customer requirements is considered as a computer based system (CBS).**
- **Once this CBS forming a functional unit of I & C system then it is to be treated as computer based digital I&C system**
  - **Hardware components**
  - **Software components**

Classification of the CBS



Classification of the CBS

- **Newly Developed Systems (NDS)/Custom Built (CB)**

  If a system is not readily available in the market and not meeting all the desired requirements specified by the designer/customer then it categories as NDS/CB. These are designed & developed from the scratch.

  A separate IV&V Process is to be followed for NDS/CB

Classification of the CBS

- **Pre Developed Systems (PDS)**

  (Also known as pre-existing software (PSW) based on Component Based Software Engineering (CBSE))

- **PDS are previously designed and developed systems and already being in service in nuclear applications or other non-nuclear/industrial applications. These are further classified as:**

  - **Certified PDS (Cert.-PDS)**
  - **Commercial/Industrial PDS (Comm.-PDS)**

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Classification of the CBS

- **In case of Cert.-PDS**, the development life cycle process, IV&V review process and regulatory review process of a computer based system would have been already completed in the past as per the standard regulatory requirements and it is being used in the NPP. If this qualified system is considered for deployment of the identical applications, then it is considered as Cert.-PDS.
- In this case system validation is carried out for confirmation of the system build, safety, security, functional and performance requirements.
- The previous design, development documents & their corresponding reports are to be audited to ensure that the product is developed as per SDLC

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Classification of the CBS

- **In case of Comm.-PDS**, the system is already designed & developed for industrial applications and it is readily available in the commercial market with past operational experience history and meeting the desired functional & performance requirements of the user/designer.
- Such potential systems are to be evaluated for their suitability, quality and formally validated before deployment in safety and safety related systems in the nuclear applications of NPP.

  A separate IV&V Process is to be followed Comm.-PDS

Classification of the CBS

- **Embedded System (ES)**

  These are the intelligent systems or smart instruments with built-in or preloaded software and input output interfaces only.

  e.g. smart sensors/actuators, embedded controllers, etc

  A separate IV&V process is to be followed for ES

- **GDS**

  These systems are designed for specific application/purpose and can be used in design and implementation of digital I&C systems as building blocks or. e.g. platform specific hardware/software, testing board, backplane/motherboards etc. These are to be treated as NDS and platform level qualification are to be carried out

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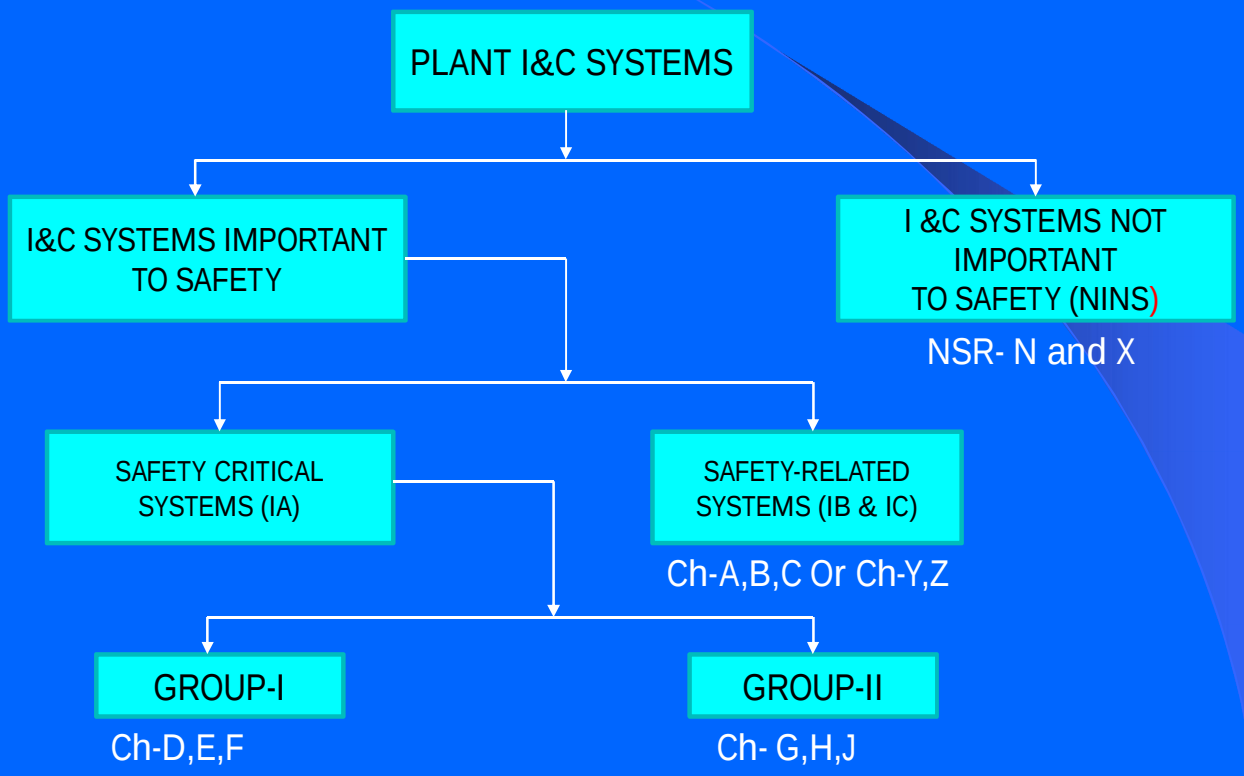
Safety Classification of I&C CBS (PHWR)

Based on AERB-SG-D-1 and IEC-61226



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What is Software?
What is Quality?

Software: As per AERB D-25

The set of logical statements/instructions that make computer hardware perform certain task of control, protection and monitoring. e. g. application software, driver software, OS, compiler, etc

Quality:

"A characteristic or attribute of an item". It is a measurable characteristics and physically compared with known standards properties like electrical parameters

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What is Software Quality?
Finally what is Software Quality Assurance (SQA)?

Software Quality: IEEE-729

The composite characteristics of software that determine the degree to which the software in use will meet the requirement of the specifications or the expectation of the user

Software Quality Assurance: IEC 880

A planned and systematic patterns of all the actions necessary to provide adequate confidence that the **product** conforms the established technical requirements of the user/designer

A set of activity designed to evaluate the **process** by which the desired **product** is developed or manufactured

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How to assure the quality of **Process** and **Product**?

A set of systematic activities with the evidences to demonstrate the ability of the hardware and software processes to manufacture the hardware and software products or a system that is fit for the desired application

There are number of ways, methods, models, & automated tools being followed to ascertain the quality of the process and the product . But at NPCIL,

- **IV&V Process which is followed concurrently with design, development, manufacturing and deployment life cycle of the system**

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What is IV & V ?

- **Independent:**
  It is Technically, Managerially & Financially Independent Process

- V&V personnel are not involved in the design/development of the system (***T. I.)***
- A separate Group at organization level reporting to top management/CEO (***M. I.)***
- Not involved in Budget estimation/control for development/procurement ***(F. I.)***

What is IV & V ?

Verification:

The process of determining whether or not the product of each phase of development process of CBS fulfils all the requirements imposed by the previous phase

- **Basically it is a review process at various phases/stage to**
  - Ensure that applicable standards/codes are followed for the development of product
  - Ensure that all the essential documents are available and the content of the document is correct, consistent & complete to meet the specified requirements.
  - Ensure that the product(s) is safe, reliable, maintainable and operable.
  - Ensure the required certifications are available

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What is IV & V ?

Validation:

Testing and evaluation of the integrated Computer Based System (Both hardware and software) to demonstrate the compliance with the functional, performance and interface requirements

- **Basically it is a testing process at various phases/stages to**
  - Demonstrate the product is built correctly and incorporated all the specified system requirements
  - Demonstrate all the intended functions in the intended environment.
  - Develop of the confidence level of end user

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Finally what is IV & V?

- **IV&V is[1]**

  Technically it is a branch of systems engineering to help the organization for building up the confidence & quality into the hardware & software throughout the life cycle of the system.

IV&V is[2]

A series of technical and management activities performed by someone other than the designer & developer of a system to improve the quality and reliability of the system and to assure that the delivered product satisfy the user's operational & maintenance requirements.

[1] IEEE Standard 1012-1998 (Introduction)
[2] Robert O. Lewis, Independent Verification and Validation, 1992 (Essential Definitions)

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Why IV&V is required? What are the benefits?

- Provides an objective assessment & the evidences for both the process and product throughout the SDLC
- Provides correct information in correct time to designer/developer/manufacturer regarding hardware & software quality & performance so that corrective action can be taken
- Creates a trust level or confidence level
- Creates a cultural shift from better to the best practices/tools in design/development process
- To ensure the followings
  - 3Cs: consistency, correctness & completeness
  - Traceability right from the rrequirements to implementation
  - Reliability and Availability (through HRA)
  - Operability and Maintainability
  - Safety of equipment & plant (through SSAR for SF & CCF)
  - Security, (Software Access Control)

Why IV&V is required? What are the benefits?

- More over, when the product is built correctly
  - The organization has documented evidences that the finish product meets all specified requirements for the hardware & software.
  - The organization has minimized the project execution TIME and in turn saved the MONEY
  - The user is able to use the hardware & software productively within his/her organization. (O&M)
  - The project wise list of anomalies (detected & corrected) is available so the reoccurrence/repetition of similar event can be avoided in the future project (Designers & Developers)

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When to perform IV&V?

- In-Phase/Concurrent Full IV&V
  - Most comprehensive level
  - Performed in parallel with system design, development, procurement, customization, testing and the final acceptance of the system for end user
- Partial IV&V
  - Begins anywhere during implementation or coding phase
  - Has little effect/influence on requirements
- Endgame IV&V
  - Focuses primarily on the integration and test phases at the end of the implementation of the project
  - Little benefit
- Audit Level IV&V
  - Minimal efforts to determine adequacy of development processes/practices followed
  - To audit the documentations, test reports, etc as an evidence

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What could be cost of IV&V process?

- IV&V Effort dependent on desired integrity level, complexity, nature of the application and size of the products or projects

In case of full IV&V[1]

– The IV&V cost vary between 10% and 50% of the software & hardware development cost and it depend on the size of the project

– This cost is compensated through early detection & correction of the faults/errors in the SDLC and savings could end up paying for the IV&V effort

In case of the partial IV&V[1]

Lower the IV&V cost, but if error detected during testing than the cost for fixing the error may be 10 to 50 times of the development cost and further it depend on the size of the project.

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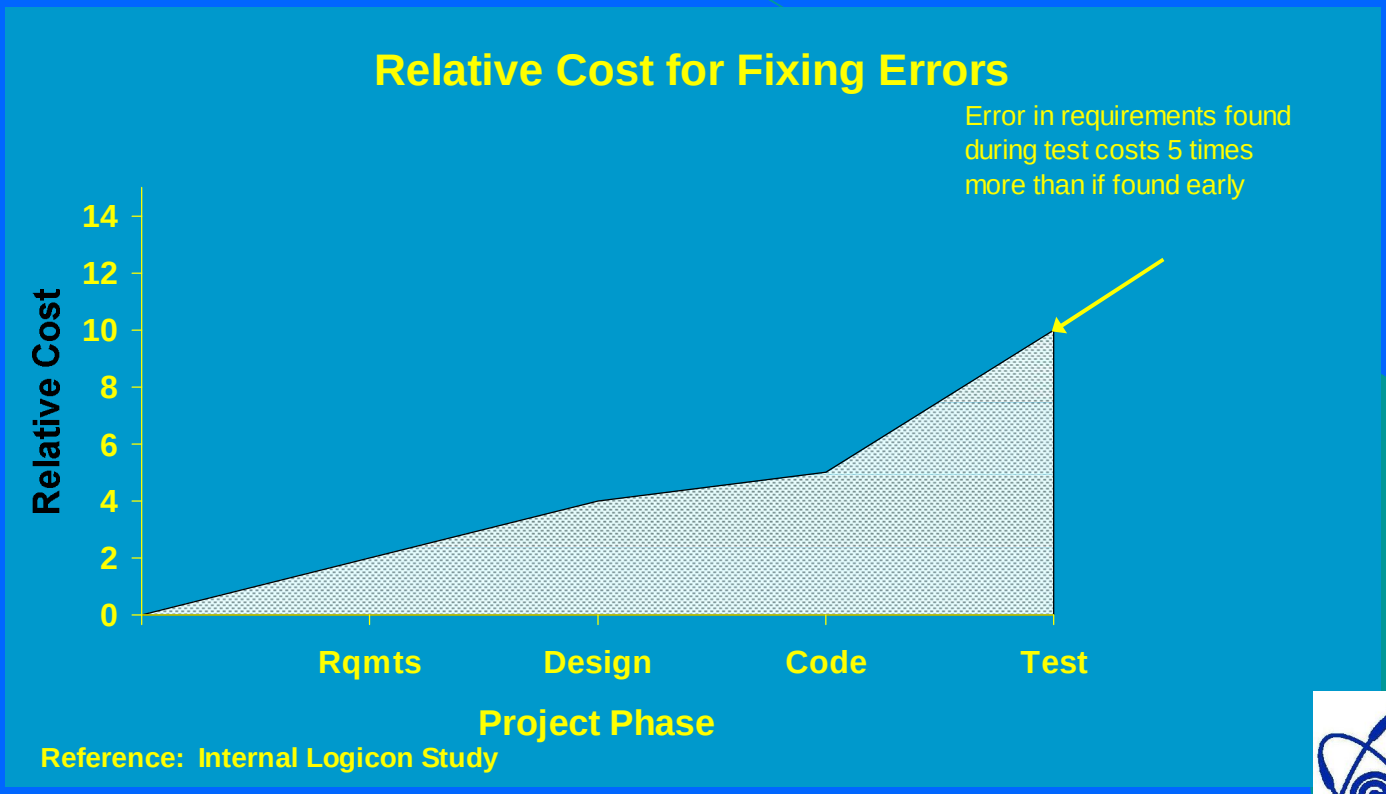
IV&V is for– Cost Benefit



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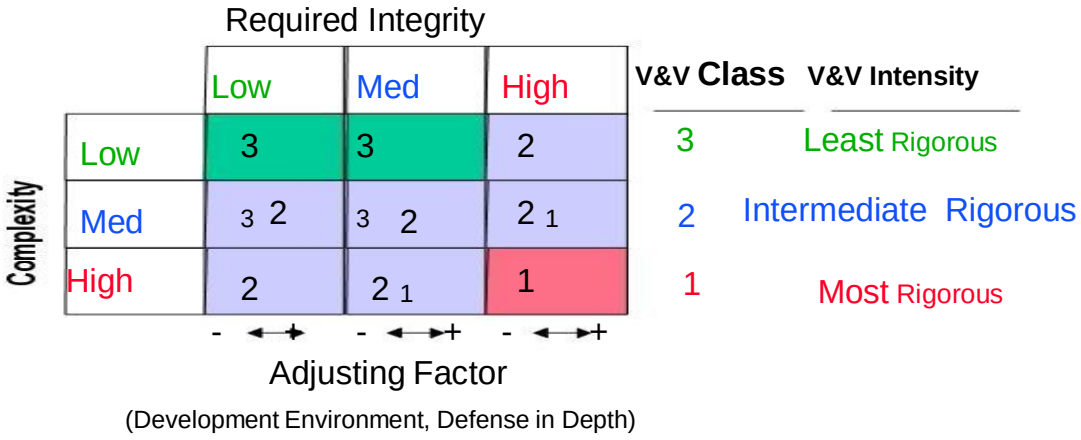
IV &V Intensity or Rigorousness

The V&V intensity, which identifies the degree of rigor necessary during the system development life cycle



Source: From Hand book for V&V of digital systems by EPRI California

How to perform IV&V Process on PDS??

PDS life Cycle Phases

Requirements Phase

- Review of System Requirements (Pre-tendering Review)

Procurement Phase

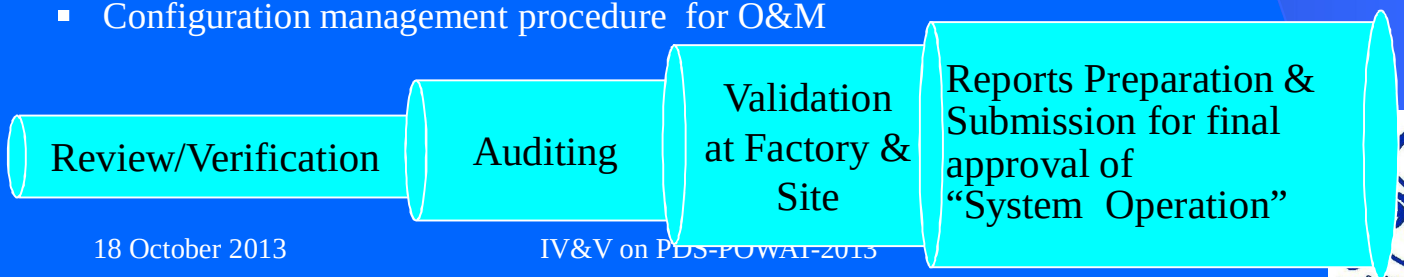
- ***Evaluation:*** *During purchase recommendation*
- Review of manufacturing process, product quality & suitability, auditing of developer/manufacturer documents/reports for original /prototype product and its development process, operating experience documents
- ***Execution:*** *Mainly Configuration & Customization*
- Review of design, planning, customization & configuration process
- System Safety Analysis for implementation of safety functions, SF & CCF
- Hardware Reliability Analysis for reliability & availability
- System validation at manufacturer's premises

Deployment Phase

- System Validation at Site

Operation & Maintenance Phase :

- Configuration management procedure for O&M



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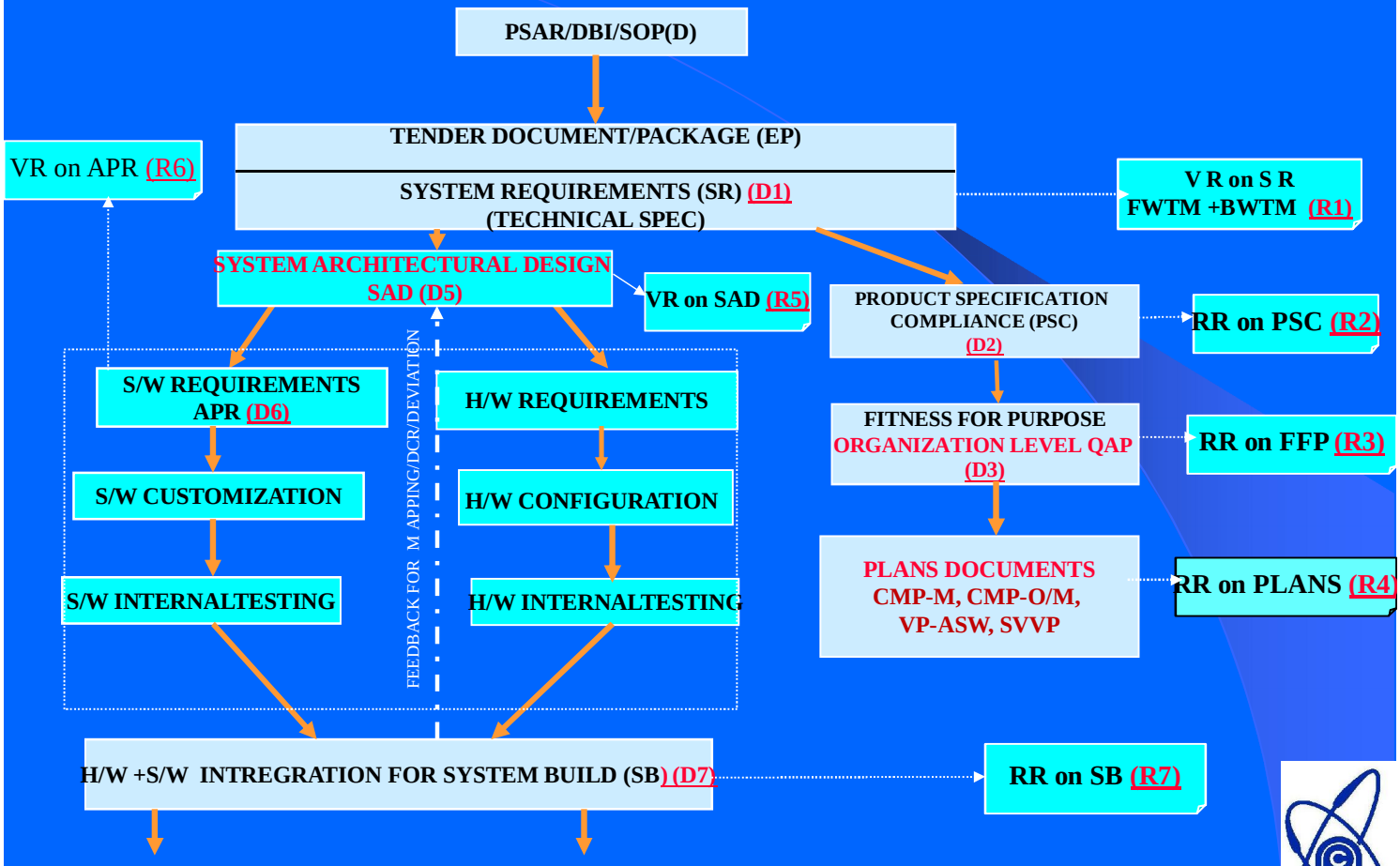
IV&V Process for the Comm.-PDS



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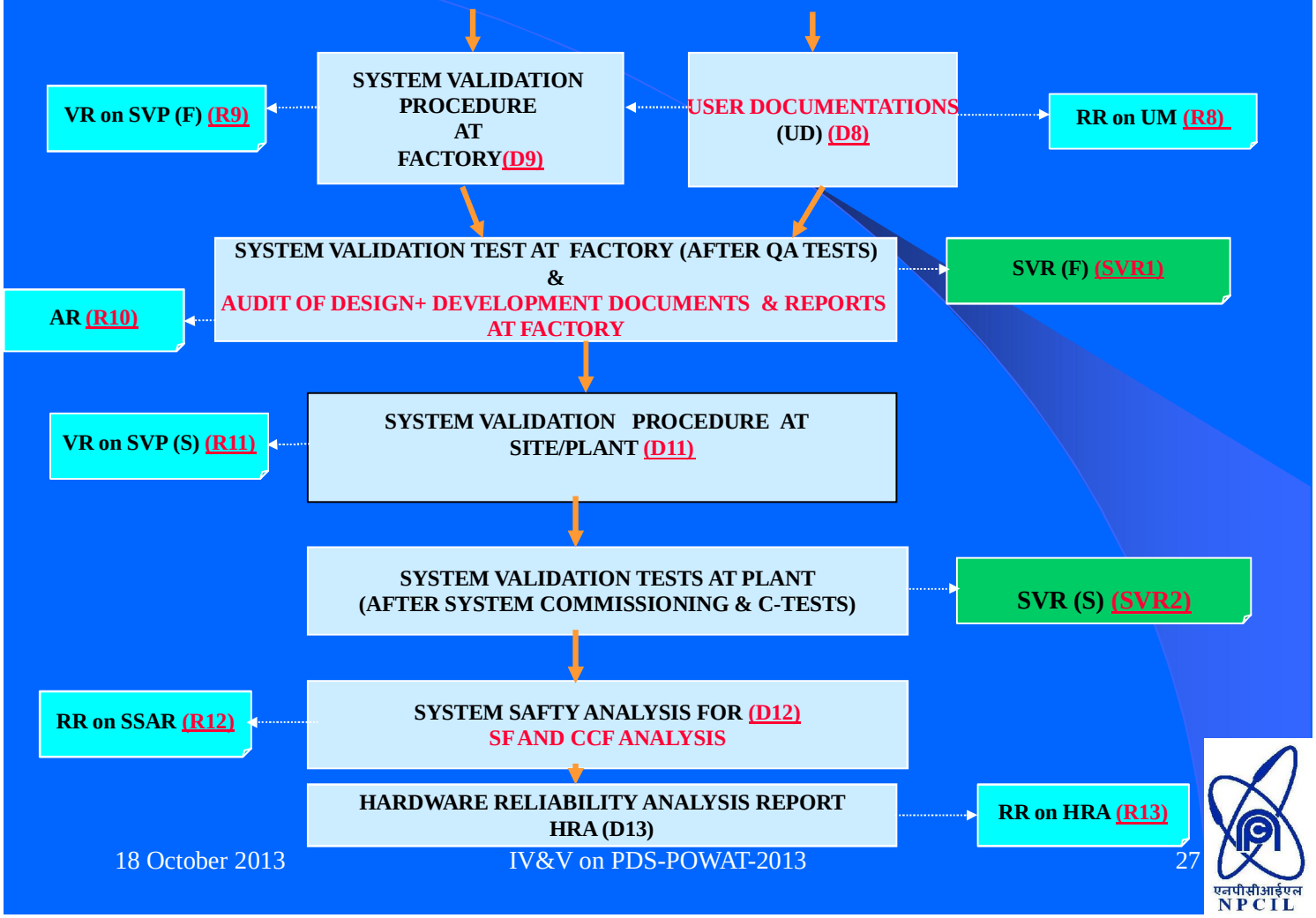
IV&V Process for the Comm-PDS (COTS) system Contd…..



Deliverables
(Design Documents & Reports for the Comm.-PDS)

1	System Requirements (SR) along with PSAR
2	Product Specification Compliance (PSC)
3	Fitness for Purpose (FFP) including OQAP
4	System Architecture Design (SAD)
5	Configuration Management Plan (CMP)-Manu
6	System Build (SB)
7	Verification Plan-Application Software
8	Users Documentations (UD)
9	System Verification and Validation Plan (SVVP)
10	Application Programming Requirements (APR)
11	System Validation Procedure at Factory (SVP-F)
12	System Validation Procedure at Site (SVP-S)
13	System Safety Analysis Report (SSAR) to cover SF and CCF
14	Hardware Reliability Analysis (HRA)
15	Configuration Management Procedure-O&M

1	VR on SR
2	RR on PSC
3	RR on FFP
4	VR on SAD
5	RR on CMP-M
6	RR on SB
7	RR on VP-ASW
8	RR on UD
9	VR ON SVVP
10	VR on APR
11	VR on SVP-F
12	VR on SVP-S
13	RR on SSAR
14	RR on HRA
15	RR on CMP-O&M

1	SVR-L/F
2	SVR-S

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Design, Development Documents & Reports on basic system to be Audited

1	Hardware QA Plan (HQAP)	Audit Report
2	Software QA Plan (SQAP)	
3	Software Requirement Specification (SRS)	
4	Software Design Description (SDD)	
5	Programming Guidelines (PG)	
6	System Integration and Test Plan (Sys ITPlan)	
7	System Integration and Test Report (Sys ITR)	
8	System Validation Report (SVR)	
9	Verification Reports on SRS	
10	Verification report on SDD	
11	Verification Report for Source Code/Software Implementation	
12	Certification Report for Compliance on • General Design Criteria, • Safety Criteria • Quality Policy	

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Challenges during IV&V process on PDS

- The IV&V process is not concurrent or in phase with the design, development and deployment. This is the biggest challenge for early detection of errors/faults and correction
- Many times the system Integrators/Venders are not fully aware the IV&V process as compare to OEM
- Non-availability of essential design & development documents with required information for the offered system
- Non-availability of design & development documents along with their corresponding reports on original/previous system

Challenges during IV&V process on PDS

- Many times the feedback on the implementation of the pending suggestions/recommendations is not available
- The details of incremental changes/modifications are not available/provided
- The source codes for the application software is not provided specifically for safety class-IA & IB due to IPR & commercial issues
- The certificates/reports on the qualification of the software tools are costly affair
- Many times the SR is not fully understood by Venders then a vender driven design is imposed

Conclusion

- IV&V is a set of technical activities performed concurrently by Independent Team on CBS for a given project right from its design, development to deployment (operational) stage.
- It develops the confidence level that the system has been built and deployed correctly and completely as per desired h/w configuration and s/w customization to meet the indented safety, security, functional and performance requirements for safety of the project/plant.
- It creates the desired set of the design & development documents and corresponding review/verification reports and validation test reports as an evidence.

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THANK YOU
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Design of Electromagnetically shielded cabinet for Indian Nuclear Power Plants

Virendrakumar Wankhede

Neeraj Agrawal

Anand Behre

Nuclear Power Corporation of India Limited

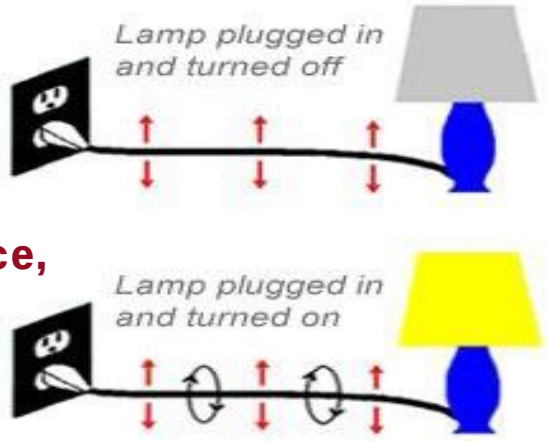
ISA(D)POWAT- 2013, Delhi, April 12th -13th, 2013

OVERVIEW

- Environment in Nuclear Power Plants (NPPs)
- Electromagnetic Interference (EMI)
- Electromagnetic Compatibility (EMC)
- EMC Design Fundamentals
- Special requirements of cabinets in NPP
- Basis for deciding
  - Qualifying Frequency ranges
  - Shielding Effectiveness (SE) limits
  - Standards for testing
- Design features
- Challenges faced

ENVIRONMENT IN INDIAN NPPs

- **In a nuclear power plant, instruments are subjected to**
  - **Varying operating environment due to effect of**
    - **Temperature,**
    - **Pressure,**
    - **Humidity,**
    - **Electromagnetic Interference,**
    - **Vibration,**
    - **Radiation etc.**

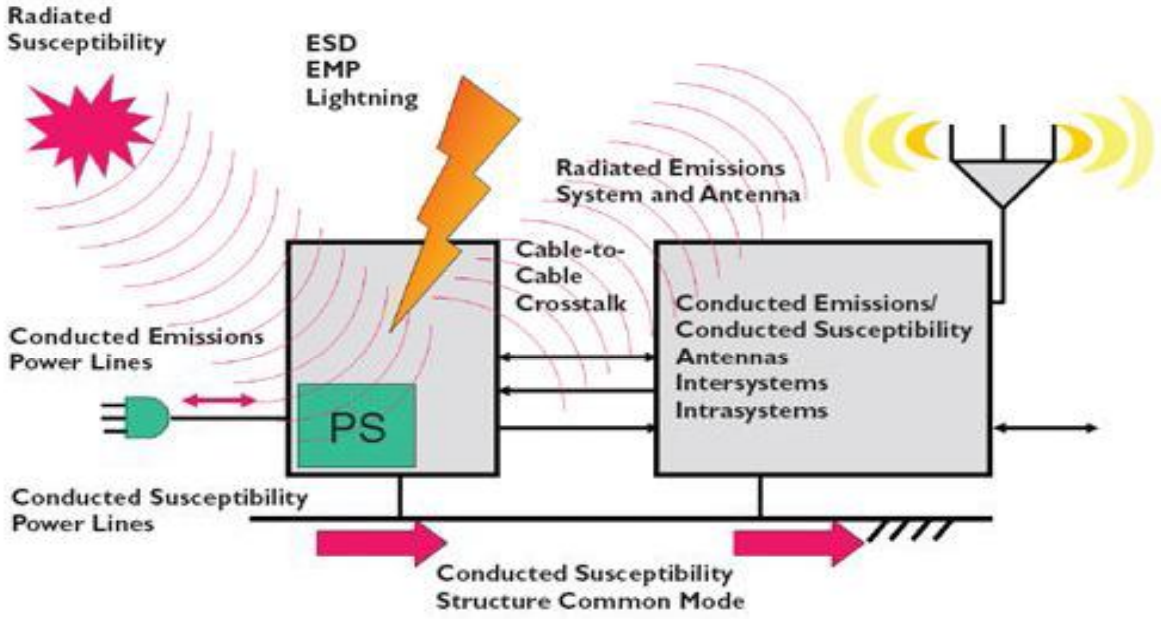


ENVIRONMENT IN INDIAN NPPs

- Here we are going to discuss the EMC aspect of cabinet Design in NPPs
- Systems and Instruments in NPPs designed to withstand EMI conditions
- NPCIL periodically carries out EMI/EMC survey at its plants
- In these surveys, analysis and in operating experiences, electromagnetic fields due to EMI observed in NPPs

ELECTROMAGNETIC INTERFERANCE

All electronics emit magnetic and electrical energy, if this energy unintentionally interacts with another device and causes it to malfunction, then it is considered interference.



ELECTROMAGNETIC INTERFERANCE

Normal picture

Interference caused by a thermostat

Interference caused by a computer

Interference caused by a motor

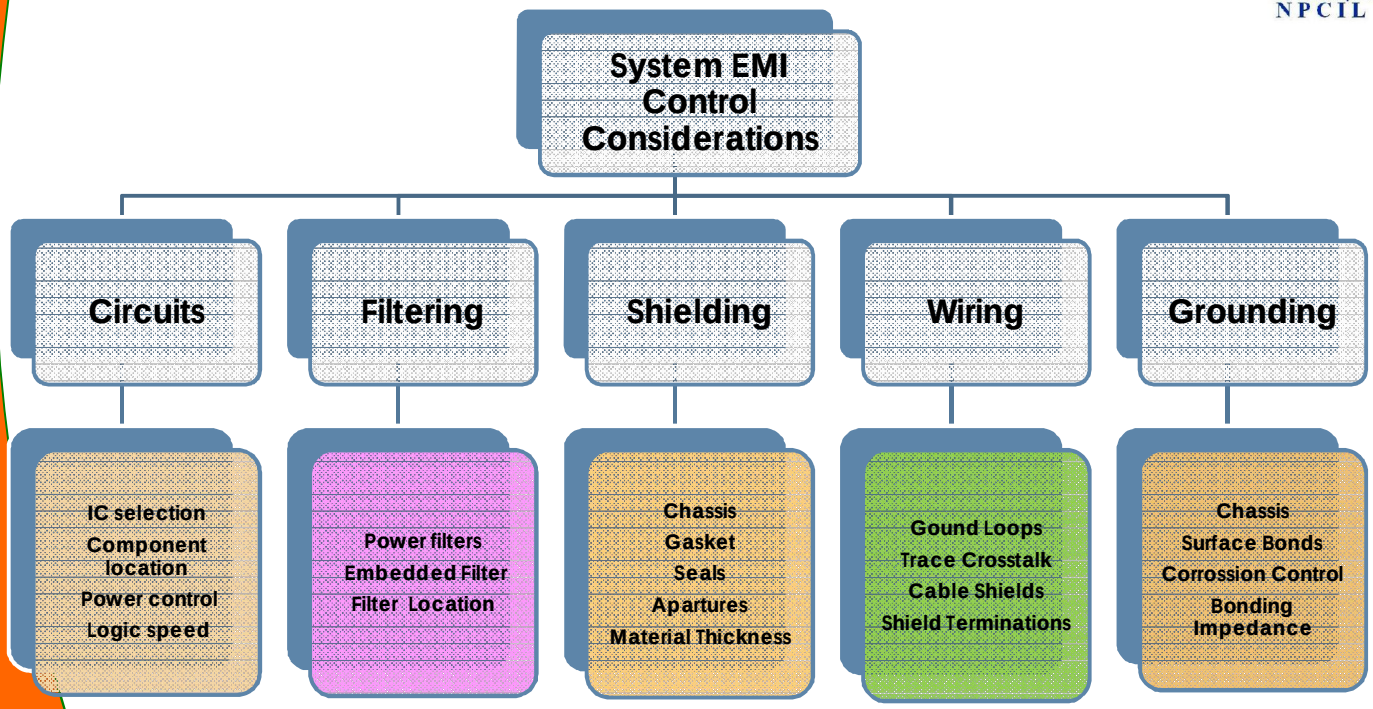
ELECTROMAGNETIC INTERFERANCE

- Most EMI is caused by frequencies in the range of 1 KHz and 10 GHz
- Common sources of EMI in a plant includes motors, mobile phones, radar transmitters, appliances, static electricity and lightning
  - Integrated circuits (ICs) are also source of EMI

ELECTROMAGNETIC COMPATIBILITY (EMC)

"EMC is the capability of an electrical or electronic circuit to function satisfactorily in electromagnetic environment without interfering with it"

EMC FUNDAMENTALS



EFFECTS OF HOLES ON EMC

No slots longer than λ/10

(λ: wave length of the interference to be screened)

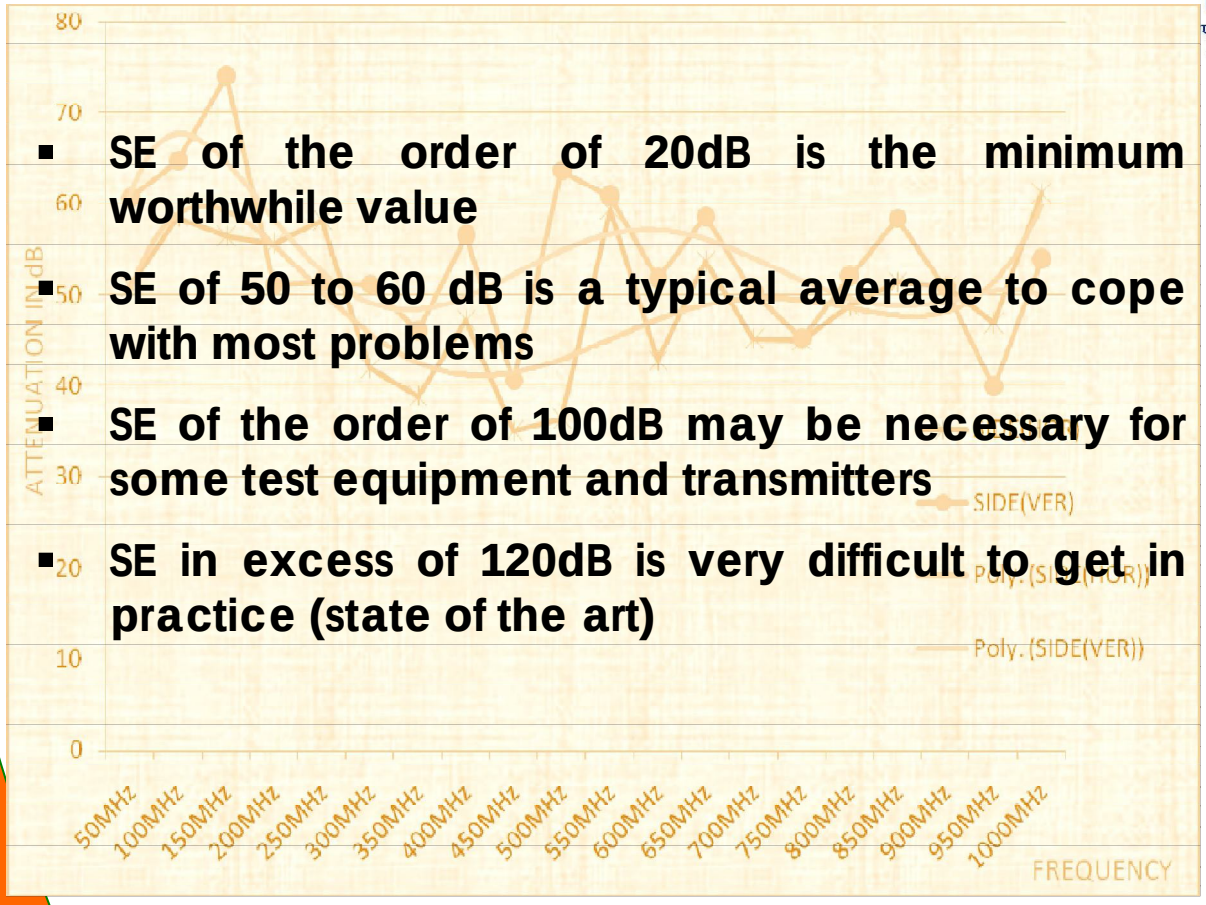
Frequency	Wave length (λ)	Admissible slot length (λ/10)
30 MHz	10.0 m	1000 mm
100 MHz	3.0 m	300 mm
300 MHz	1.0 m	100 mm
1 GHz	0.3 m	30 mm
3 GHz	0.1 m	10 mm

EMI ATTENUATION

- **Attenuation is the indicator for measuring SE**
  - **Attenuation is measured in decibels (dB) and is the ratio between field strength with and without the presence of a protective shielding**
  - **In practical a certain amount of shielding is required to minimise emissions and immunity problems**

EMI ATTENUATION

- SE of the order of 20dB is the minimum worthwhile value
- SE of 50 to 60 dB is a typical average to cope with most problems
- SE of the order of 100dB may be necessary for some test equipment and transmitters
- SE in excess of 120dB is very difficult to get in practice (state of the art)



SHIELDING REPRESENTATION

- 20 dB shield -Weakening by the factor 10
- 40 dB shield -Weakening by the factor 100
- 60 dB shield -Weakening by the factor 1000

and so on.

SHIELDING REPRESENTATION

SIDES EXPOSED DURING TESTING

SHIELDING REPRESENTATION

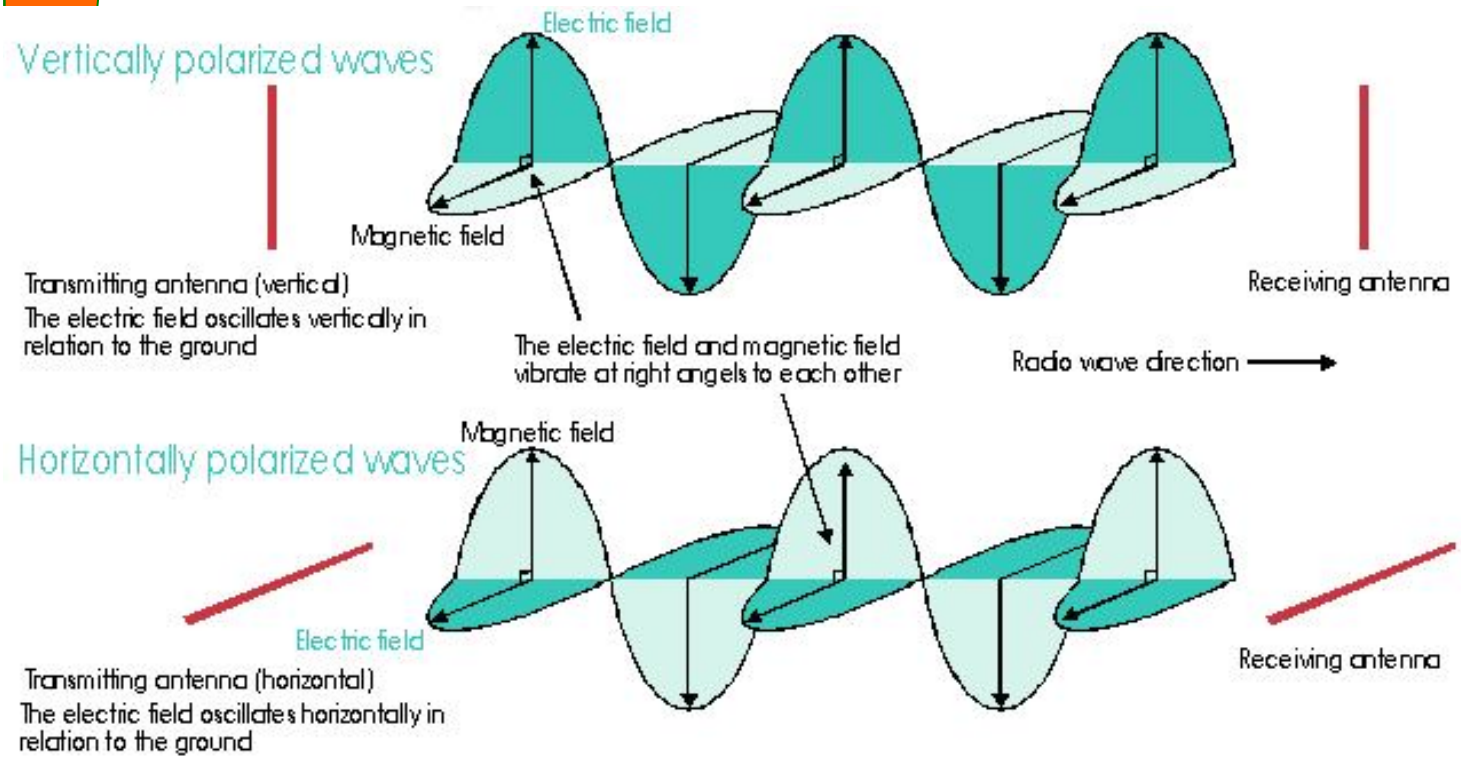
SIDES EXPOSED DURING TESTING

Horizontal

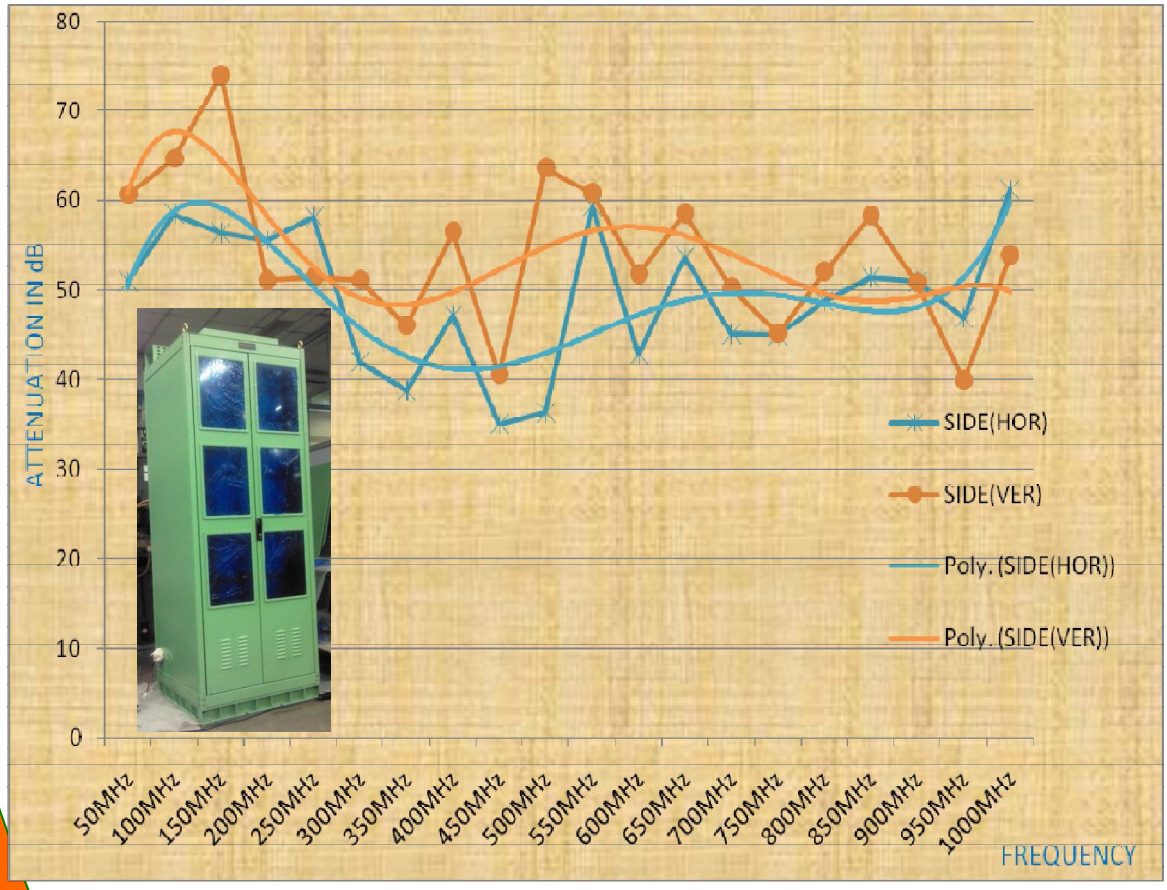
Vertical

SHIELDING REPRESENTATION

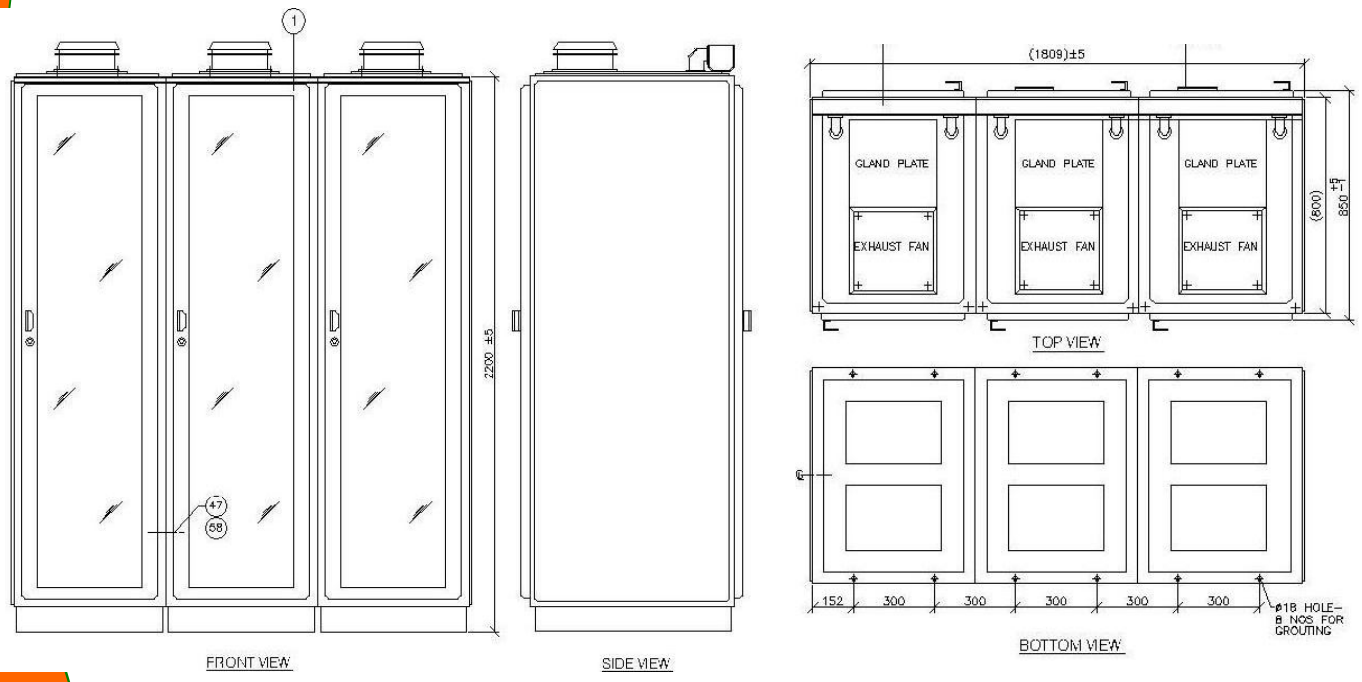
SIDES EXPOSED DURING TESTING



SHIELDING REPRESENTATION



CABINET OF NPP

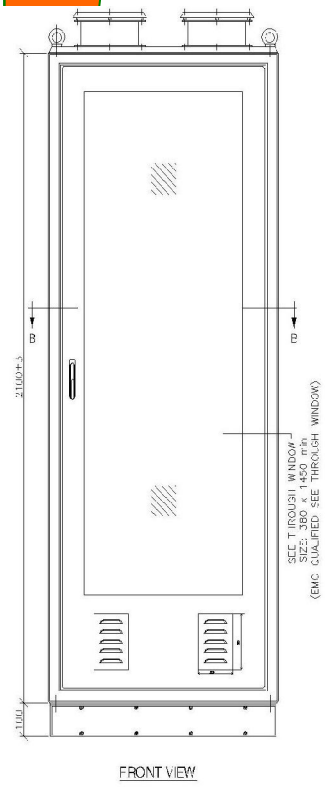


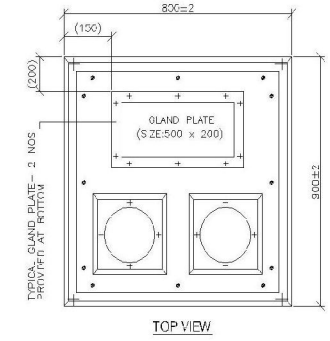
SPECIAL REQUIREMENTS

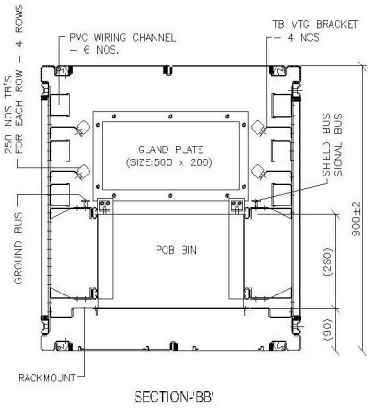
OF

NEW CABINET

NEW CABINET DESIGN







- 800mm(W) x 900mm(D) x 2200mmm (H)
- Ventilation and Illumination
- Bottom cable entry
- Shielding from inside to outside as well as outside to inside
- Front door with see-thru glass
- Shielding effectiveness
  - 10 KHz to 30 MHz- 60 dB
  - 30MHz to 1GHz- 50dB
  - 1GHz to 3GHz- 35dB
- Applicable standard for testing IEC-61587-3

BASIS FOR DECIDING THE FREQUENCY RANGE

▶FOR FREQUENCY RANGE 10 KHz-30 MHz

- Based on EMI surveys carried out by us at various operating NPPs, EMI fields were observed in this range
- But, the cabinet manufacturers in the market does not consider 10 KHz to 30 MHz frequency range for EMI/EMC protection

BASIS FOR DECIDING THE FREQUENCY RANGE

▶FOR FREQUENCY RANGE 30 MHz-3GHz

- New set of hardware modules designed by NPCIL has clock frequencies above 30 MHz range
- The Intentional transmission from Walkie-Talkie, Bluetooth devices falls in this range
- 2G/3G/4G GSM mobile services in India operates between 900 to 2300MHz
- Considering all above, frequency range from 30 MHz to 3GHz selected

BASIS FOR DECIDING SE LIMITS

- Based on performance level-3 of IEC-61587-3 average Shielding Effectiveness (SE) defined

Electric Field Attenuation Levels			
Performance Level	Average Shielding Performance		
	Frequency Range		
	30MHz to 230MHz	230MHz to 1GHz	1GHz to 3GHz
3	60 dB	50 dB	35 dB

- The range from 10 KHz to 30 MHz is not considered for EMC qualification; however in this range the readings obtained for further study

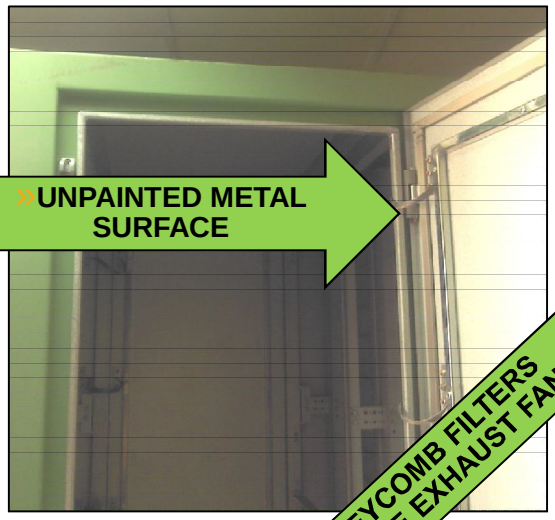
BASIS FOR SELECTING THE STANDARD

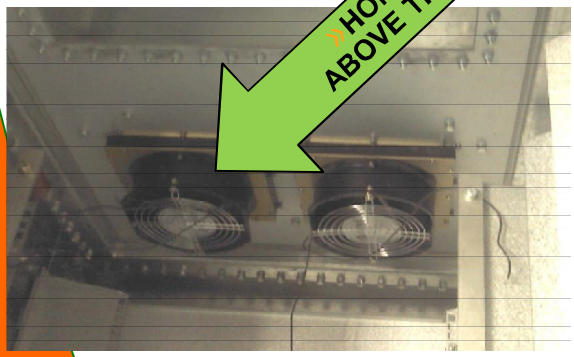
- IEC-61000-5-7, IEC-61587-3 and IEEE – 299 standards studied
- IEC-61000-5-7 applicable for enclosures of all dimensions, whereas IEC-61587-3 applicable only for cabinet sizes upto 900mm (D) x 1200mm (W) x 2200mm (H)
- IEC-61000-5-7 covers the total frequency spectrum from 10 KHz to 40 GHz, whereas IEC-61587-3 covers frequency range from 30 MHz to 2GHz

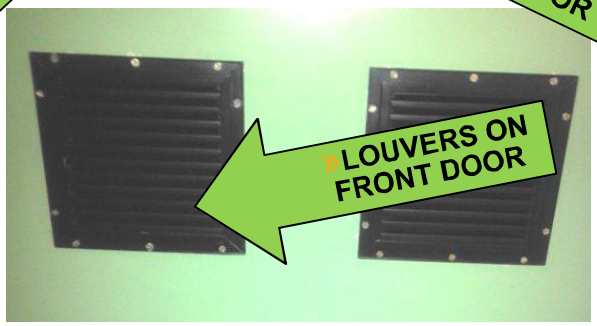
BASIS FOR SELECTING THE STANDARD

- IEC-61587-3 gives guidance for selecting attenuation values
- As per these standards, an enclosure exhibits a higher SE after installation of components and modules than does the empty enclosure. Also an enclosure exhibits a low SE after installing additional penetrations
- IEEE – 299- Covers frequencies from 9 KHz to 18 GHz, but this standard applies to any enclosure having a smallest linear dimension =< 2 m.
- IEEE - P299.1 – Covers enclosures having all dimensions between 0.1 m and 2 m. but this standard is in draft stage.
- IEC-61587-3-2006 - latest available standard for SE of cabinet and is used for testing of new cabinet

NEW CABINET DESIGN FEATURES

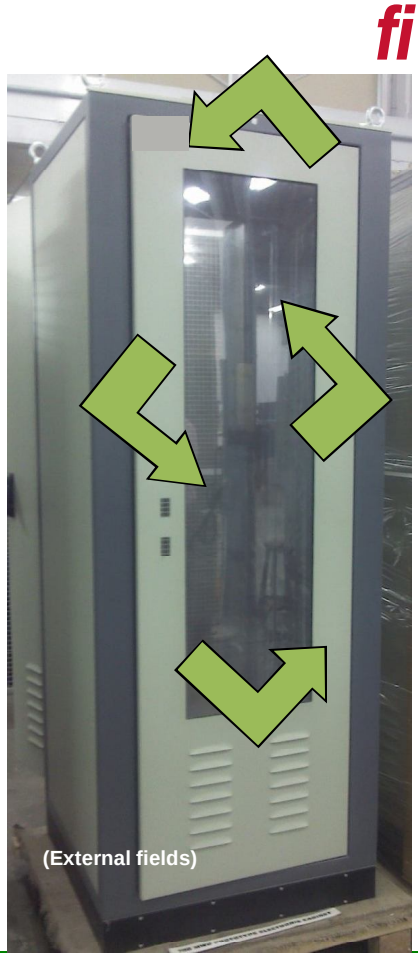




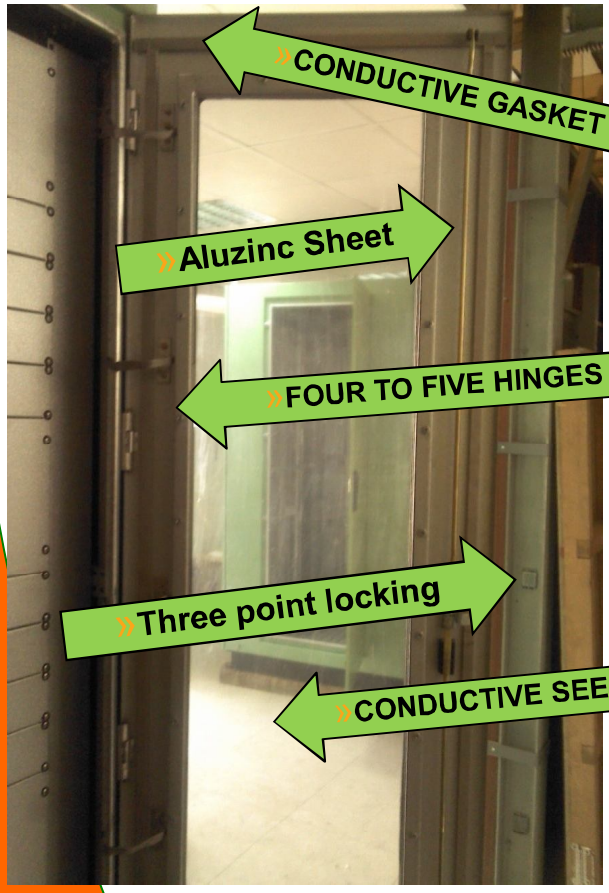


- Larger viewing openings with see-thru glass
- RFI suppressed LED illumination

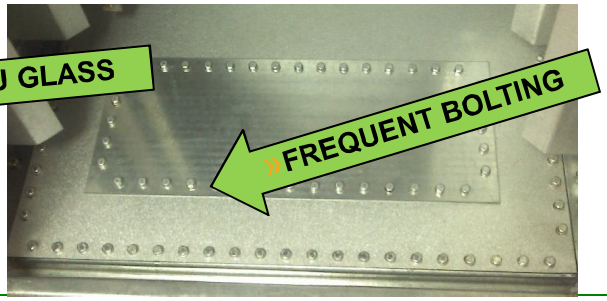
Shielding against interference fields



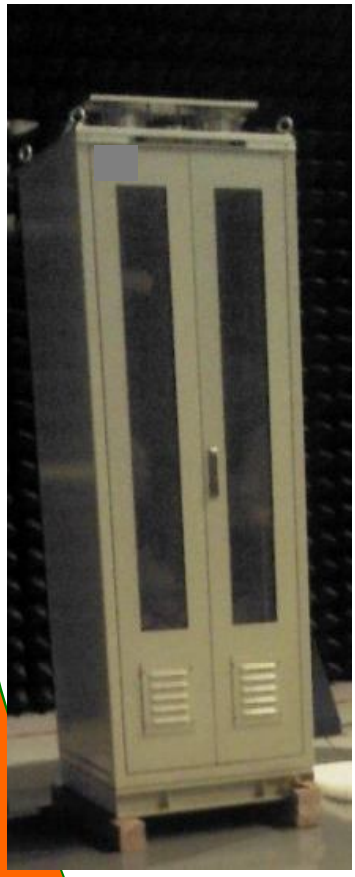
CHALLENGES FACED



- Qualify the design for EMC & seismic with large see-thru glass
- To shield the louvers and exhaust fan openings without compromising ventilation
- Ensuring the metal to metal contacts at doors
- Painting of the outer side keeping inside unpainted



INITIAL CABINET SE TESTING



NPCIL tested and studied test results of different EMC cabinets of known manufacturers. Salient features of these cabinets are

Panel-1

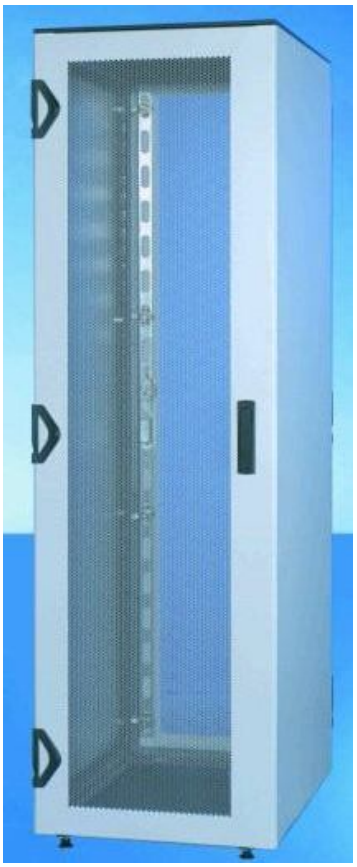
1. **800mm (W) x 800mm (D) x 2200mm (H)**
2. **Front Double door with see-thru glass**
3. **Rear Double door**
4. **Inside Zinc plated conductive surface**
5. **No honeycomb filters**
6. **Exhaust fans at the top**

INITIAL CABINET SE TESTING

Panel-2

1. 800mm (W) x 800mm (D) x 2200mm (H)
2. Front Double door with slotted see-thru glass
3. Rear Double doors
4. Inside Zinc Plated conductive surface
5. No honeycomb filters
6. Exhaust fans at the top

INITIAL CABINET SE TESTING



Panel-3

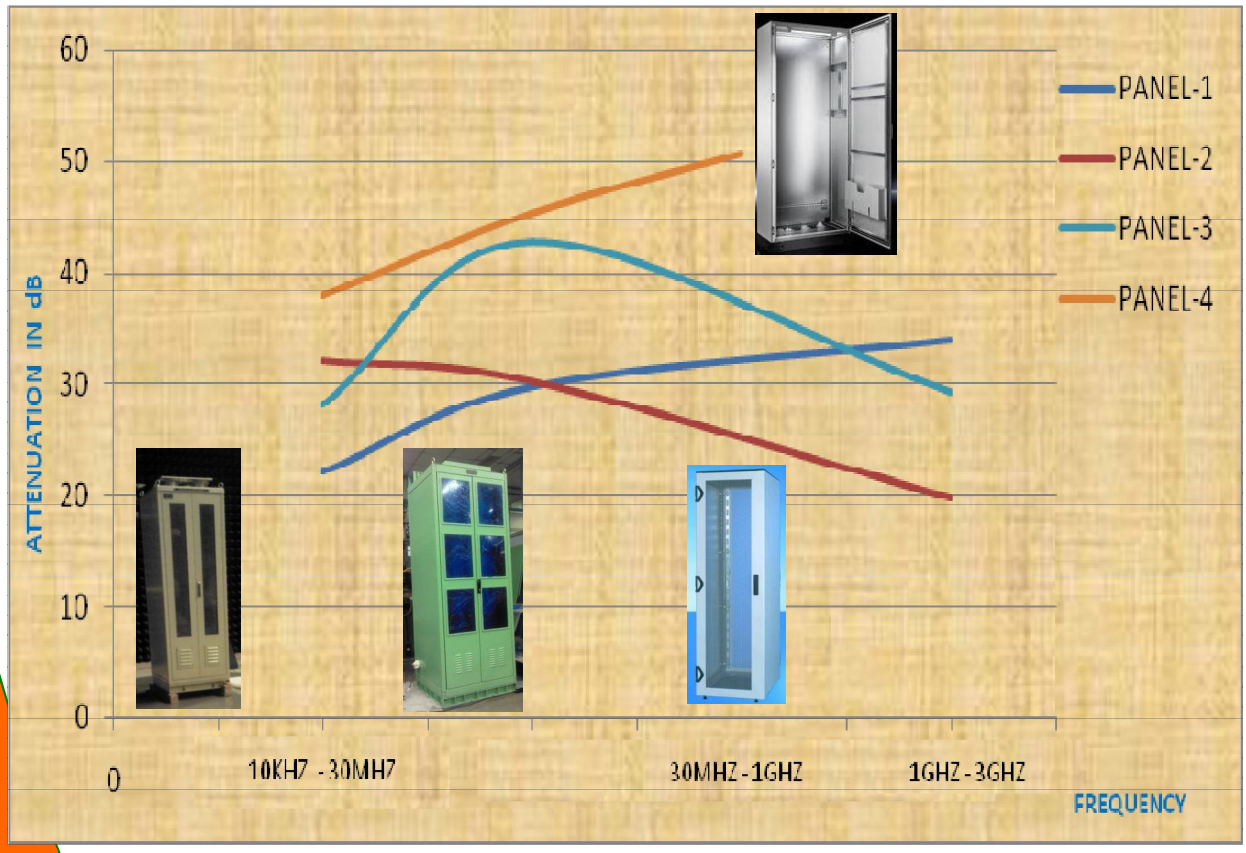
1. 800mm(W) x 900mm(D) x 2200mm(H)
2. Inside Zinc plated conductive surface
3. Perforated single front and rear doors
4. No exhaust fan openings
5. No louvers

INITIAL CABINET SE TESTING

Panel-4

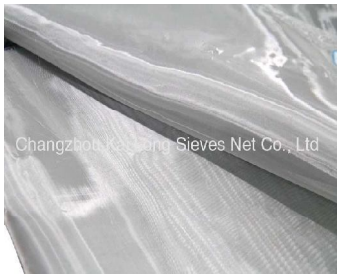
1. 800mm (W) x 800mm (D) x 2200mm (H)
2. Inside Zinc plated conductive surface
3. Complete Closed panel, No see thru glass
4. No openings
5. No exhaust fans
6. No louvers

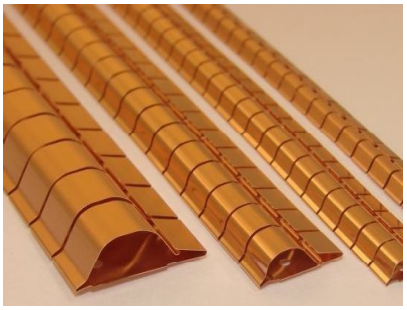
INITIAL CABINET SE TESTING



IMPROVEMENTS DONE AFTER TESTING

- The cabinet fabricated using Aluzinc (AlZn) sheet
- Conductive Gaskets
- Conductive mesh
- Honeycomb filter
- Improved workmanship





TESTING AFTER IMPROVEMENTS

After carrying out these improvements, testing was done on two prototypes

Panel-1

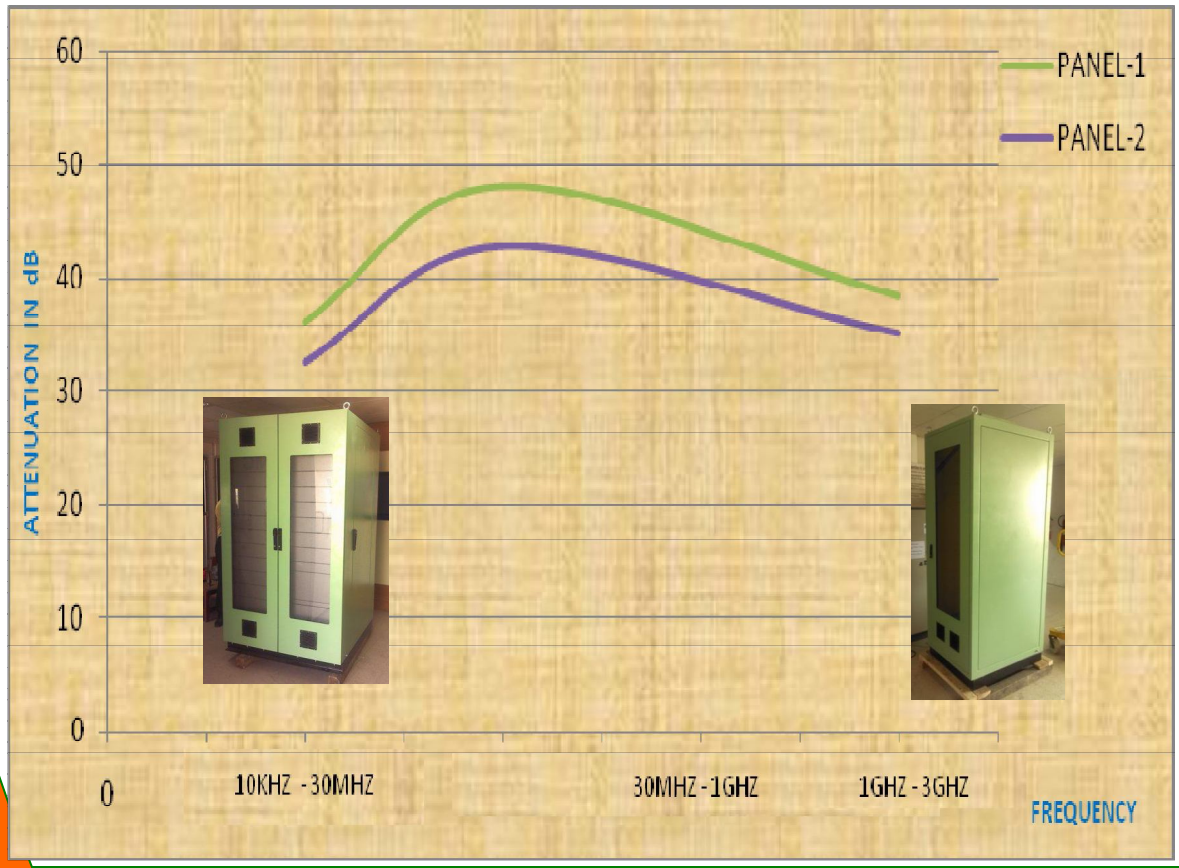
1. **1200mm (W) x 1200mm (D) x 2200mm (H)**
2. **Fabrication using AluZinc sheet steel**
3. **Front see-thru double door**
4. **Single door on each side of the panel**
5. **Rear double door**
6. **No exhaust fans**

TESTING AFTER IMPROVEMENTS

Panel-2

1. 800mm (W) x 900mm (D) x 2200mm (H)
2. Fabrication using AluZinc sheet steel
3. Front see-thru Single door
4. Rear double door
5. Exhaust fans at the top
6. Louvers at the front door
7. Honey comb filters at the openings
8. Frequent bolting

TESTING AFTER IMPROVEMENTS



CONCLUSION

- Cabinet is provided with 20mm honeycomb filters at all openings, fabrication out of aluzinc sheet, conductive mesh on the front see-thru door, ensured metal-to-metal contact, conductive gaskets along all the openings and overlapping.
- With this design reasonable SE has been achieved. Further improvement is in progress to achieve the desired SE.

THANK YOU

Environmental Qualification of Instruments for use in Nuclear Power Plants

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Nuclear Power Corporation of India Limited, Mumbai

Presented in ISA(D)POWAT 2013, New Delhi April 12th -13th, 2013

OVERVIEW

- Introduction
- Aging of Instrument
- Environmental Qualification
- Challenges in Qualification

INTRODUCTION

INTRODUCTION

1/2

I&C in a Nuclear Power Plant has to perform functions during:

- Normal Operation
- Anticipated Operational Transients
- Design Basis Accidents
- Severe Accident

INTRODUCTION

- Instruments must perform its design functions even after degradation in performance
- Degradation in performance of instruments also happens due to aging
- Hence qualification of instrument subsequent to aging becomes an important criterion in Nuclear Power plant

AGING OF INSTRUMENTS

AGING OF INSTRUMENT

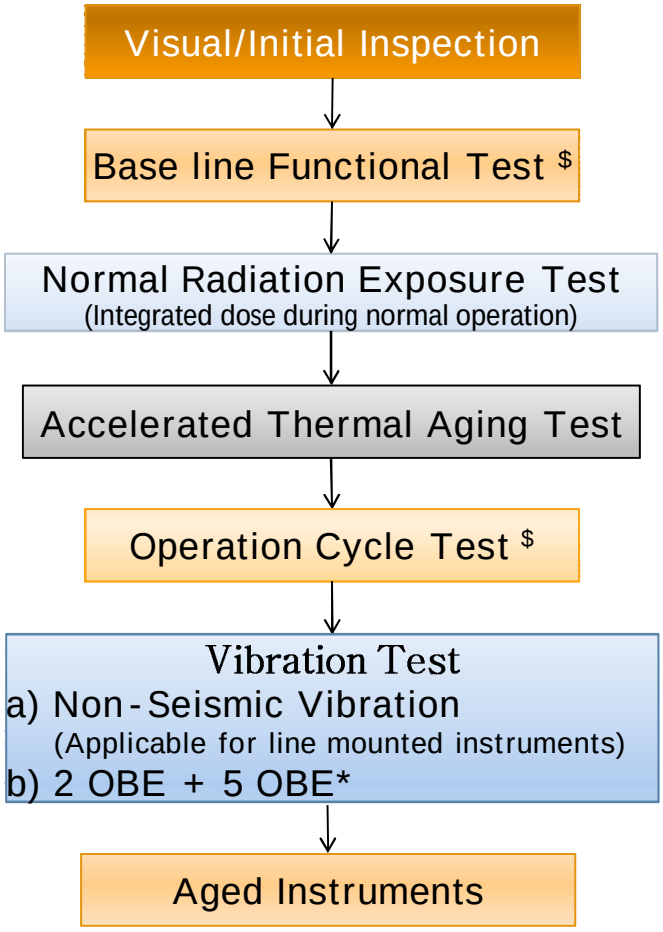
- **Before instrument is put to use its expected life in plant is decided.**
- **It can be:**
  - ✓ 10 years
  - ✓ 20 years
  - ✓ 40 years

AGING OF INSTRUMENT

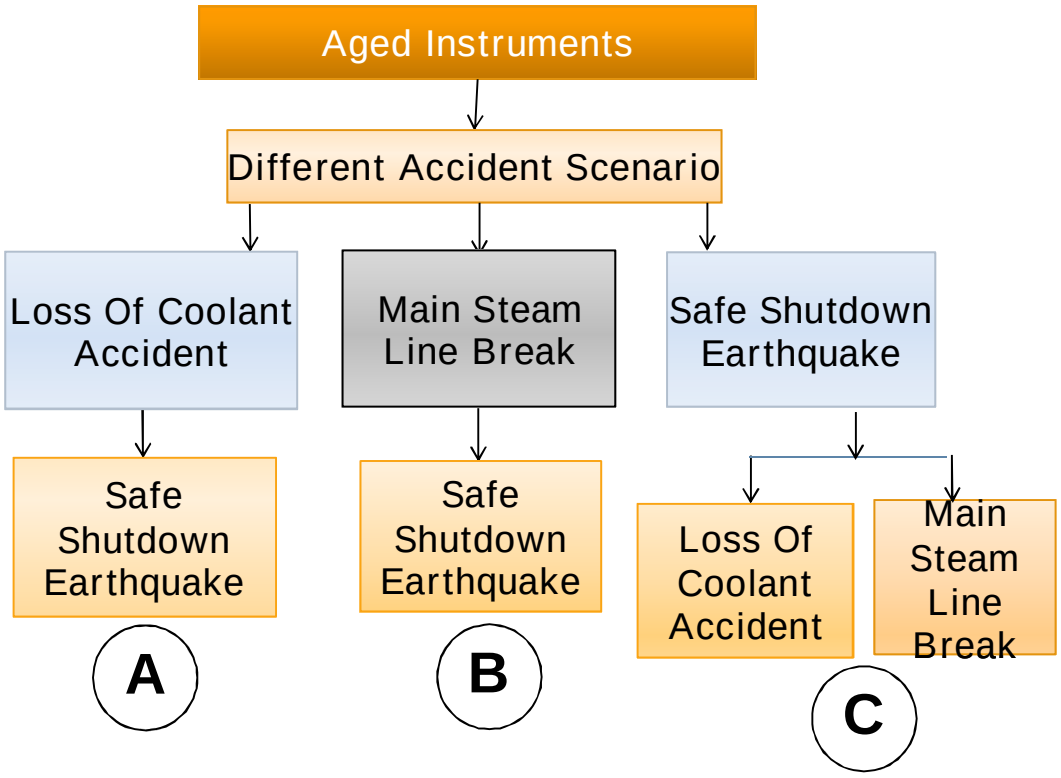
Aging of instrument takes place due to cumulative effect of following:

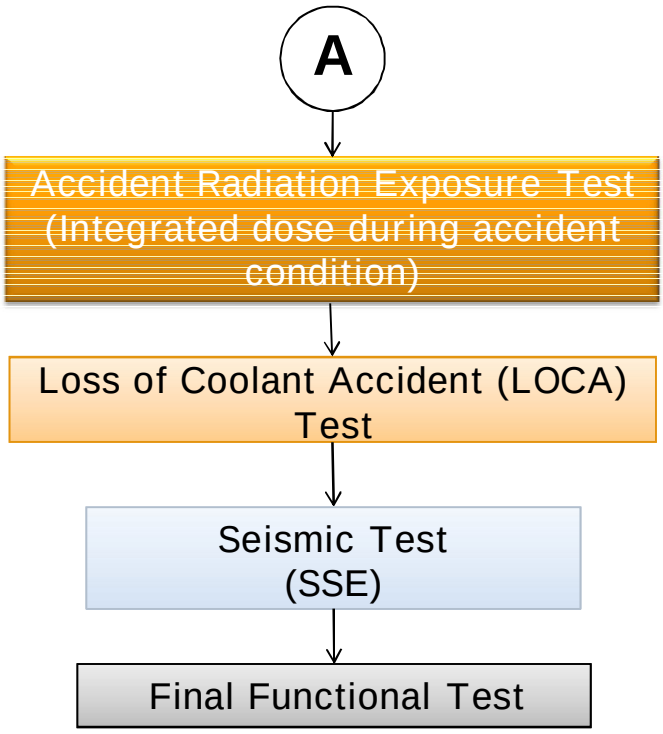
- Thermal Effect
- Radiation Effect
- Vibration Effect
- EMI Effect
- Electrical Loading
- Usage

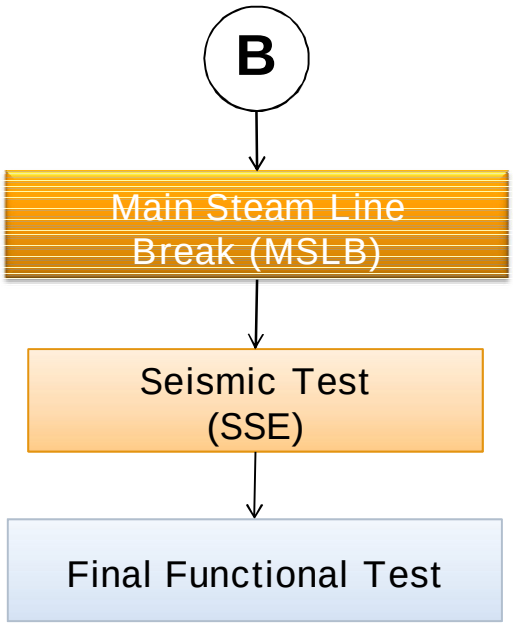
ENVIRONMENTAL QUALIFICATION

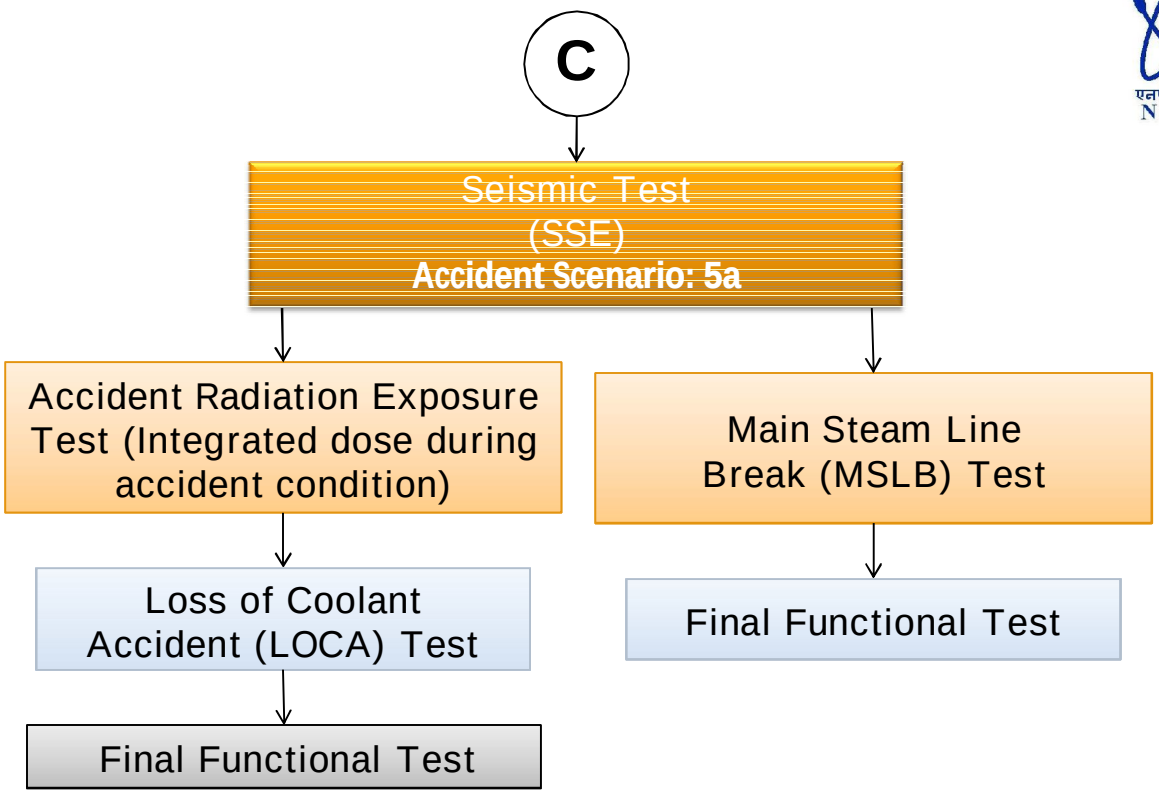


1) '$' Base line functional test and operation cycle test depends on type of instruments.
2) '*' 2 OBE cycles for 20 years of qualified life and 5 OBE cycles for 40 years of qualified life.


Aged Instruments
Different Accident Scenario
Loss Of Coolant Accident
Main Steam Line Break
Safe Shutdown Earthquake
Safe Shutdown Earthquake
Safe Shutdown Earthquake
Loss Of Coolant Accident
Main Steam Line Break
A
B
C


A
Accident Radiation Exposure Test (Integrated dose during accident condition)
Loss of Coolant Accident (LOCA) Test
Seismic Test (SSE)
Final Functional Test


B
Main Steam Line Break (MSLB)
Seismic Test (SSE)
Final Functional Test


C
Seismic Test
(SSE)
Accident Scenario: 5a
Accident Radiation Exposure Test (Integrated dose during accident condition)
Loss of Coolant Accident (LOCA) Test
Final Functional Test
Main Steam Line Break (MSLB) Test
Final Functional Test

CHALLENGES IN QUALIFICATION

CHALLENGES

- During Initial Qualification:
  - ✓ Time required for Environmental Qualification is quite large (minimum 6 to 8 months)
  - ✓ Large number of documentation is required
  - ✓ Facility available in country for these testing is limited.
- During operation of plant:
  - ✓ Maintenance of qualification during life of the plant
- Non-availability of indigenous instruments

"Phew! - I don't think I can make it to the finish line, so I'm going back!"

Nuclear Business is a Marathon not a Sprint