Safety Enhancement of Dhruva Reactor through Periodic Safety Review(PSR)

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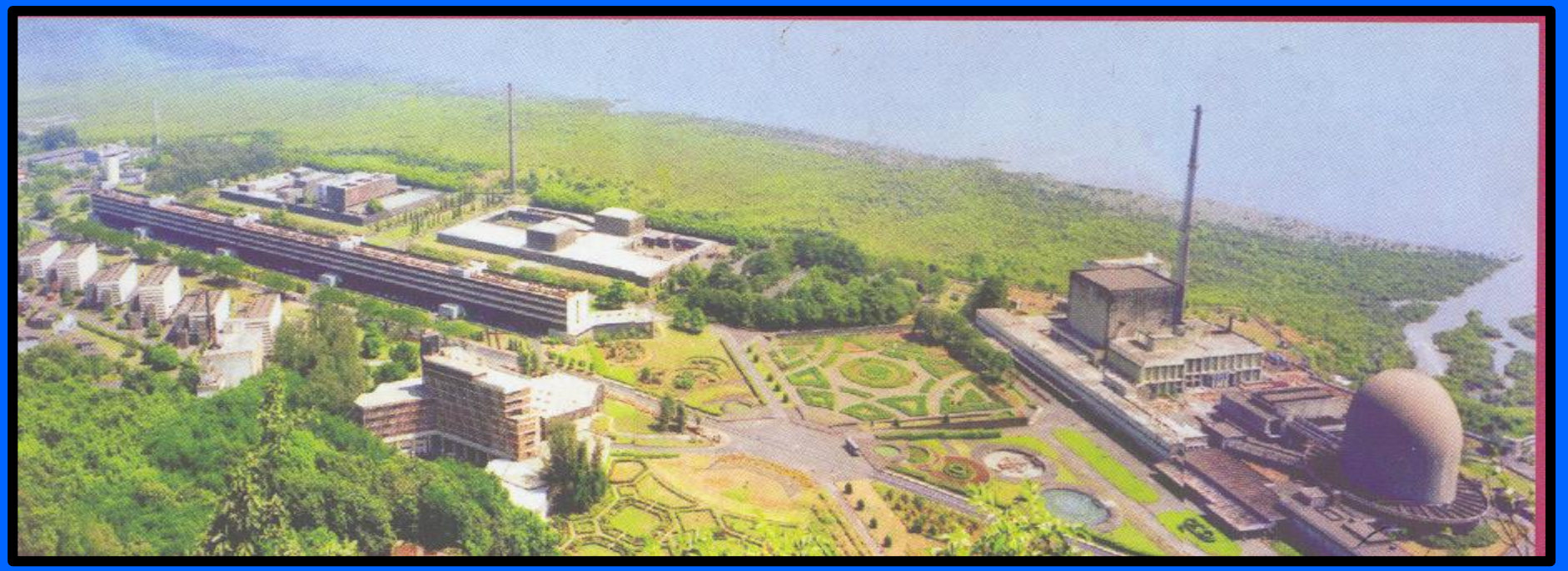
Outline of presentation

- About BARC
- About Dhruva
- About PSR and its methodology
- Safety factors review ,outcome – safety upgrades
- Conclusion

Bhabha Atomic Research Centre

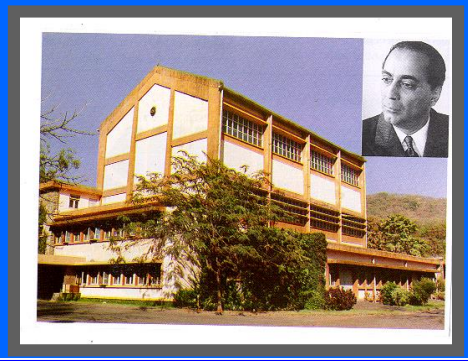


A Multi-disciplinary, Multi-scale R & D Organization. Located at Trombay with sister units located at Tarapur, Kalpakkam, Mysore, Srinagar & Gulmarg, Mt. Abu, Gauribidanur, ESLs and Seismic Stations at various places in the country

- **RESEARCH REACTORS**
- **REPROCESSING PLANT**
- **WASTE MANAGEMENT FACILITIES**
- **FUEL FABRICATION**
- **IRRADIATION FACILITIES**
- **OTHER R & D LABS**

Research Reactors at Trombay

- Apsara – 1 MWt, Pool Type, First Criticality in 1956, under up-gradation to 2 MW
- Cirus – 40 MWt, Tank Type, Critical in 1960, Permanent Status :S/D from Dec-2010
- Dhruva – 100 MWt, Tank Type, Critical in 1985 – In Operation
- 100 W AHWR Critical Facility
- More than 125 reactor- years of O & M experience with good safety record.



APSARA (1956) – The Epitome of Initiation of Indian Nuclear Programme. The Reactor was decommissioned . Construction of 2 MW upgraded APSARA in progress.

Dhruva & Cirus Reactor at BARC. (Cirus was Shutdown in 2010)

About Dhruva

First Criticality	: August 8, 1985
Rated Power	: 100 MW^{th}
Peak thermal Flux	: **1.8 X 10^{14} n/cm^2-sec**
Orientation	: Vertical Tank Type
Fuel	: Natural uranium metal
Coolant	: Heavy water
Moderator/ Reflector	: Heavy water
Reactor Regulation	: **Level control of moderator**
Primary Shutdown	: **Cadmium Shut off rods (9)**

Panoramic view of Dhruva

Periodic Safety Review (PSR)

- Periodic Safety Review is an important regulatory instrument for maintaining and improving safety throughout the operating life cycle of the nuclear reactor
- These safety reviews are of two types

- **A limited scope safety review for Renewal of Authorisation (RA) conducted every five years and**

- **A very comprehensive full scope review called Periodic Safety Review (PSR) conducted every ten years**

PSR for RAO

(Renewal of Authorization for Operation)

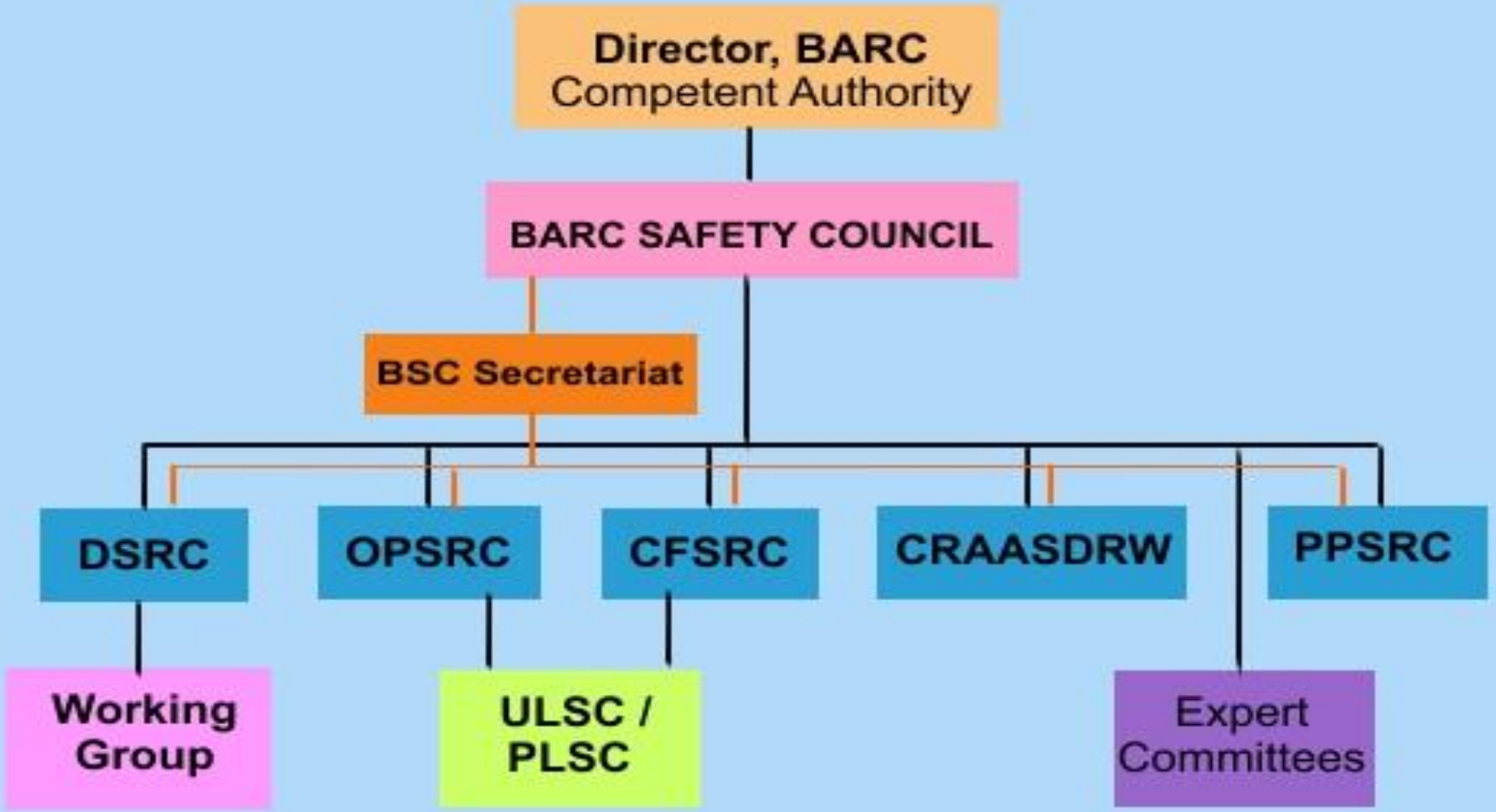
- Earlier RAO for operation of the Research Reactor was based on safety reviews and regulatory inspections by regulatory body.
- **As regulatory requirement;** PSR was made mandatory for RAO.
- Full scope PSR of Dhruva reactor was conducted for renewal of authorization for operation in year 2014 and reactor got authorization upto 2019
- The PSR has been helpful in identifying weaknesses in system configuration and implementing a few safety upgrades of Dhruva

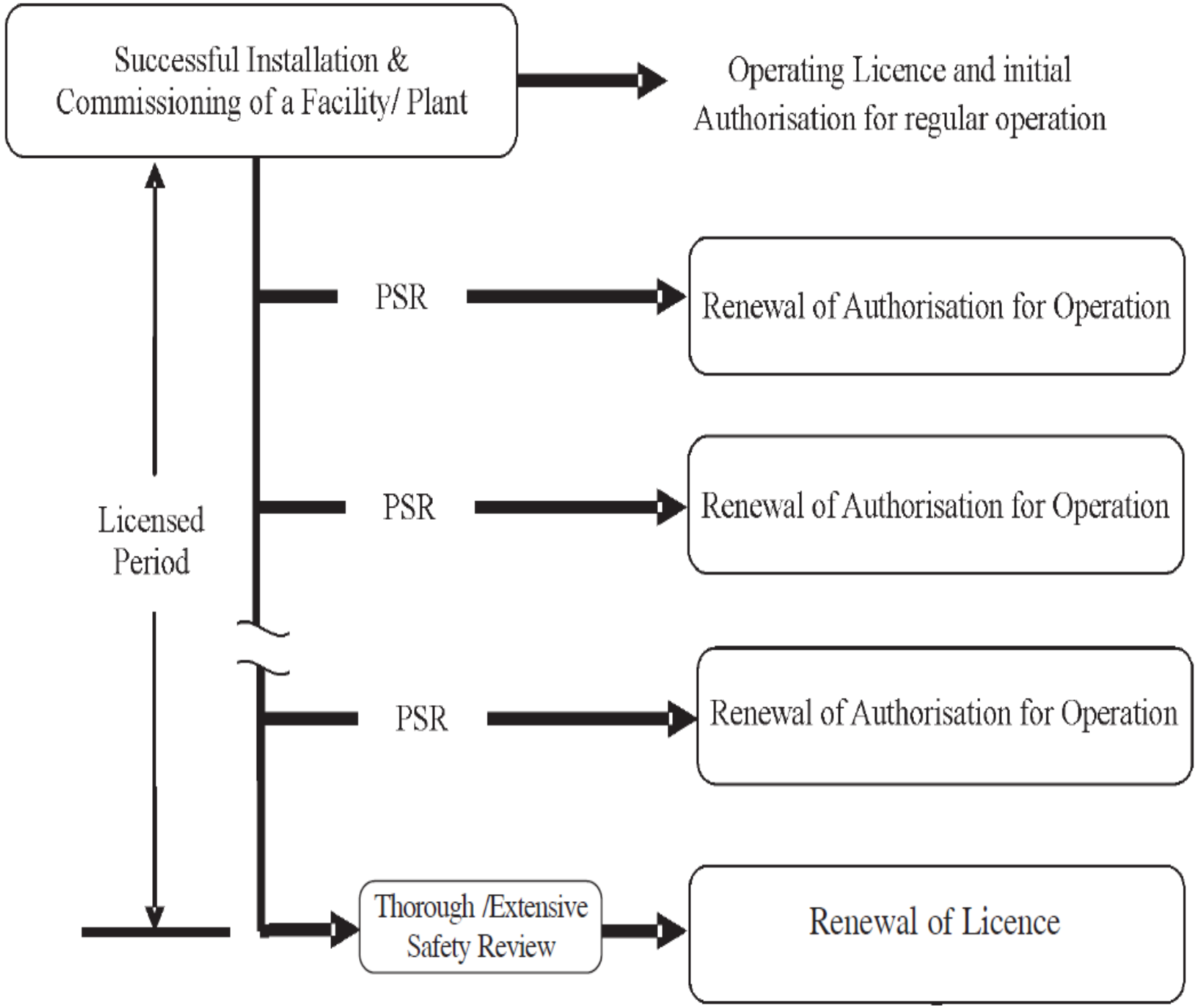
PSR for RAO

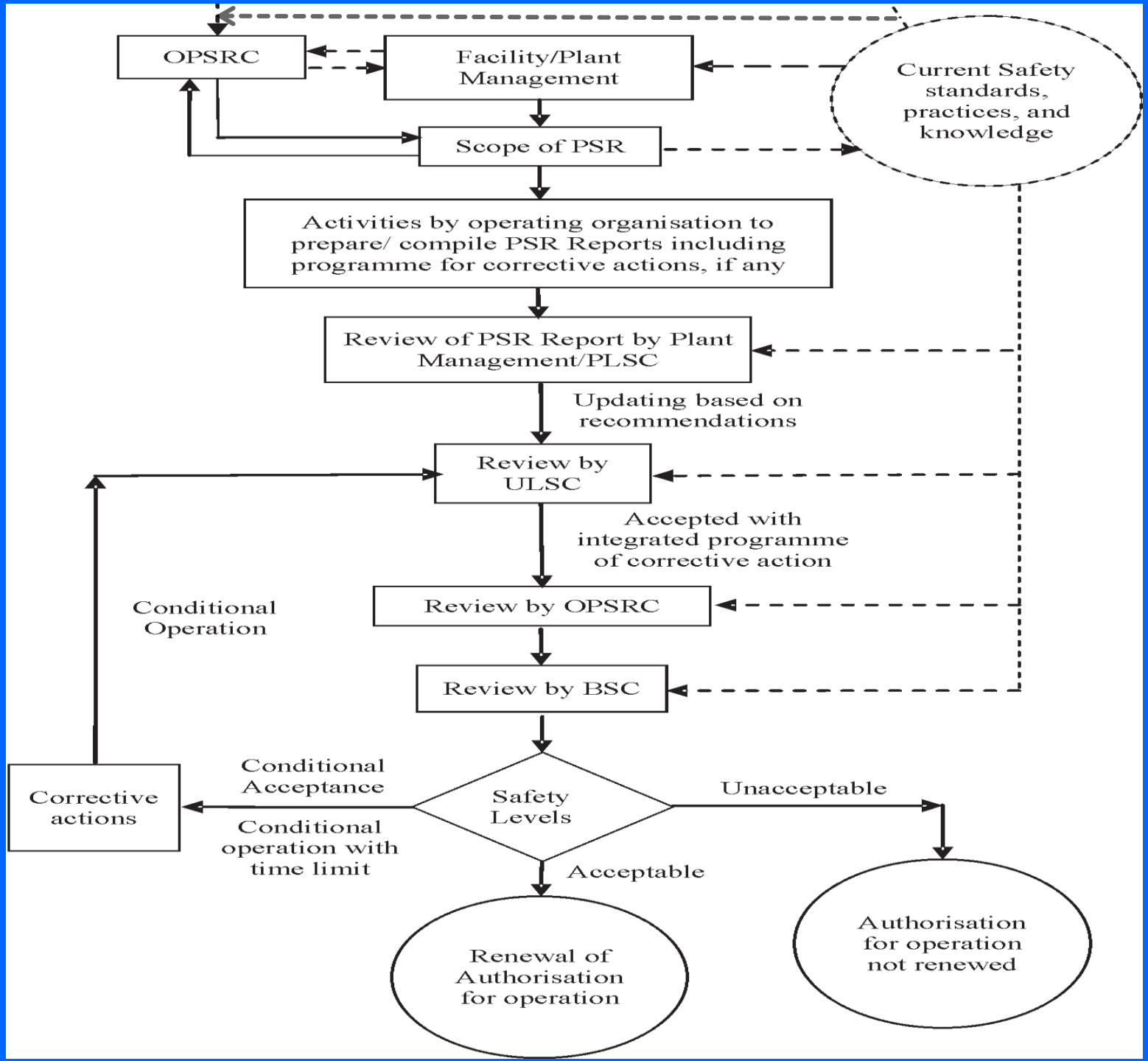
(Renewal of Authorization for Operation)

- Guidelines for PSR
- Reference documents
  - **Safety manual no. BSCS/SM/2010/1 Edition;R-0, March-2010**
  - **AERB safety guide no. AERB/SG/O-12**
  - **IAEA safety Standards Series No SSG-25**
  - **IAEA NSR-4**

Regulatory framework in BARC




Successful Installation & Commissioning of a Facility/ Plant
Operating Licence and initial Authorisation for regular operation
PSR
Renewal of Authorisation for Operation
PSR
Renewal of Authorisation for Operation
PSR
Renewal of Authorisation for Operation
Licensed Period
Thorough /Extensive Safety Review
Renewal of Licence


OPSRC
Facility/Plant Management
Current Safety standards, practices, and knowledge
Scope of PSR
Activities by operating organisation to prepare/ compile PSR Reports including programme for corrective actions, if any
Review of PSR Report by Plant Management/PLSC
Updating based on recommendations
Review by ULSC
Accepted with integrated programme of corrective action
Conditional Operation
Review by OPSRC
Review by BSC
Corrective actions
Conditional Acceptance
Safety Levels
Unacceptable
Conditional operation with time limit
Acceptable
Renewal of Authorisation for operation
Authorisation for operation not renewed

PSR: Starting point and End point

- **Starting point :** Agreement between Regulatory Body and Facility Management

  - **Scope of PSR**
  - **Objective**
  - **Time schedule**
  - **Expected outcome from PSR**

- : **End point :** Approval by regulatory body for safety improvements / corrective actions

Scope of PSR

- Adherence to technical specifications for operations
- Review of annual plant performance reports
- Review of anomaly reports , ERs and SERs
- Radioactive releases to the environment
- Radiation exposures
- System and procedural modifications
- Industrial safety
- Safety committee recommendations and compliance
- Reports of internal regulatory inspections
- Reports of external regulatory inspections and compliance for their recommendations

Scope of PSR

- Dhruva PSR took into account
  - **Cumulative effects of plant aging as Dhruva has completed more than 30 yrs. of operation**
  - **Modification carried out over the years**
  - **Feedback of operating experience**
- Review of all applicable safety factors based on guidelines
- Global assessment based on safety factors review

Objective and expected outcome

- PSR is intended to identify the strengths and shortcomings of the reactor against the requirements of **current standards/practices**

- PSR is used to identify the **modifications or upgrades** required to compensate for any safety significant shortcomings

- Review of documents of operational safety aspects will provide necessary inputs **for concluding on overall safety culture of plant**

Objective & expected outcome

- PSR is intended to be utilised for **reauthorisation of Dhruva**
- PSR will address issues related to **residual life of SSCs , aging studies** to be conducted & **refurbishment requirement**
- The report on the PSR is subjected to regulatory review in multi-tier review process for satisfactory resolution of the shortcomings

Safety factors

SF#1: Design
SF#2 : Actual condition of SSCs
SF#3 : Equipment qualification
SF#4 : Ageing
SF#5 : Hazard analysis
SF#6 : Deterministic analysis and PSA
SF#7 : Safety performance
SF#8 : Radiological protection
SF#9 : Operational feedback of other plants
SF#10 : Organization &Administration
SF#11 : Human factors
SF#12 : Procedures
SF#13 : Emergency planning
SF#14 : Radiological impact on environment

Safety factor #Design

- Comparison of plant design with current standard: IAEA NS-R-4
  - Dhruva Seismic design
    Seismic Coefficient Method
  - Seismic requalification based on Review Basis Ground Motion in progress most of the system have qualified.
  - Checking of safety margins.
- Plant performance factors-10 years
- Modifications in the plant system design

Supplementary Control panel (SCP)

- It is back up to Main Control Room. (MCR) and will carry out all safety functions like **shutdown of reactor, ensuring core cooling / containment** during inhabitability of MCR like fire and damage to MCR
- It is physically isolated from MCR. It is in different fire zone.

Safety factor # Equipment qualification

- List of Systems covered under qualification programme
  - Primary Shutdown systems
  - Back up shutdown systems
  - ECCS
  - Emergency Cooling system
  - Control and instrumentation
- Methodology of qualification under DBA (LOCA)
  - Temperature rise is nominal
  - only Relative Humidity is of concern.
  - Pressure rise is nominal

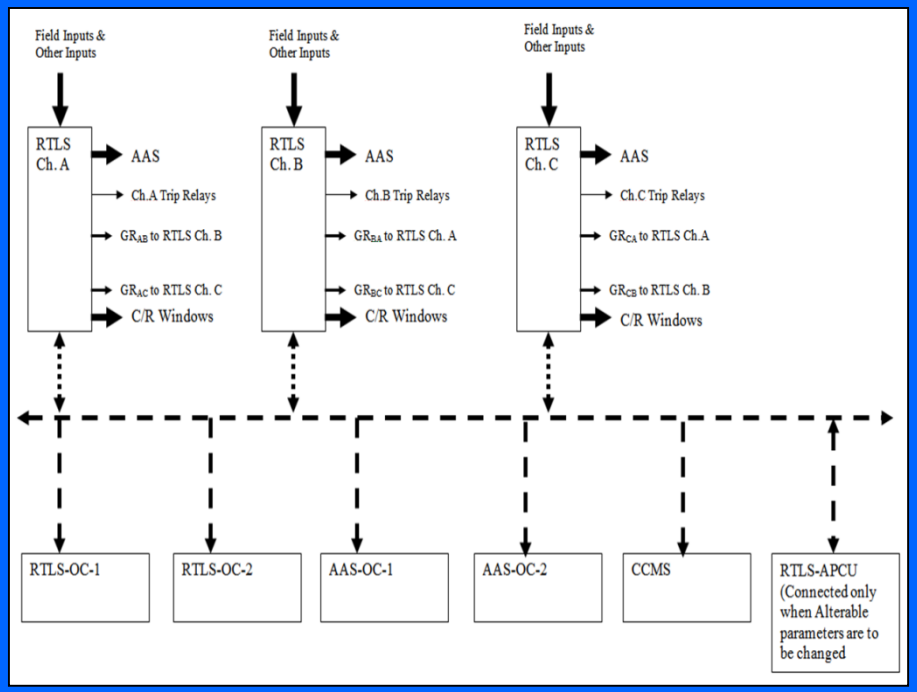
Safety factor # Ageing

- In Service Inspection programme
- Ageing Mechanisms : Obsolescence, Corrosion, fluence
- Identification of age related degradation
  - PM programme
  - Condition Monitoring
  - Calibration/ testing
  - Surveillance
  - Chemical Control
- The effectiveness of operational and maintenance programme in managing ageing of replaceable components
- Various systems have been refurbished
- NDT of Dhruva Civil structure and AMP

Reactor Trip Logic System

Up-gradation of Reactor Trip Logic System(RTLS) of Dhruva was taken up (based on TPLC-32 platform)

- It was facing obsolescence
- It had limited diagnostic features.



Secondary heat Exchangers

Heat exchangers were replaced

- Significant tube thinning
- Tube leakages
- Sea water ingress into DM water

Replacement of Main DG sets

Replacement of all diesel generators sets (500 KVA)

- To combat technical obsolescence
- Also to avoid common cause failure .

Safety factor # Hazard analysis

Internal hazards:

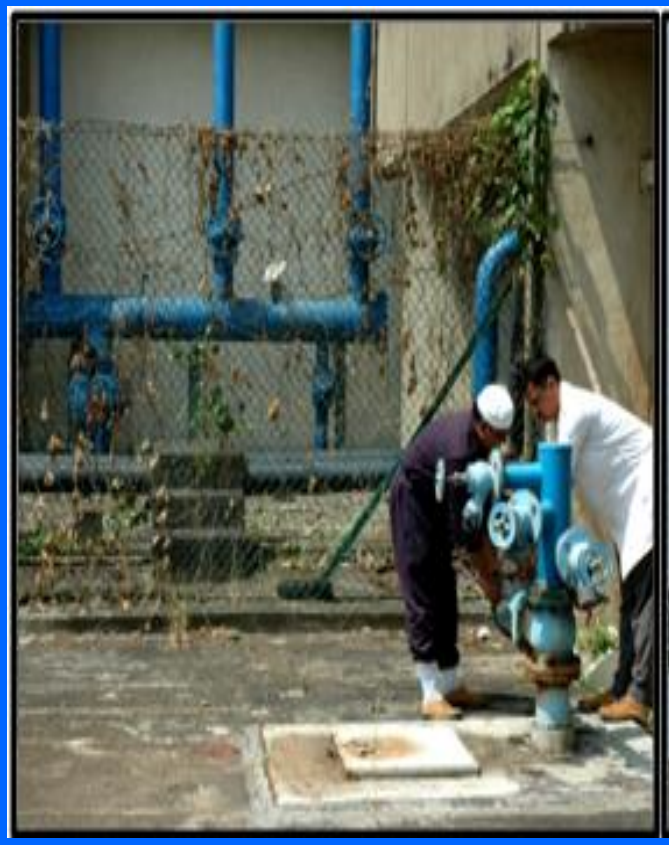
- Fire : Plant preparedness , Fire EOP, Fire Drill
- Internal flooding : EOP , pumping provision, clamping provision
- Internal Missile Attack: due to detachment of Main coolant pump flywheel-cooling ensured

External hazards

- Flooding due to heavy rains : Plant preparedness-pre-monsoon checks, deployment of submersible pumps and drainage system designed for 204 mm/ hr of precipitation.
- Seismic hazard : Seismic requalification of SSCs (for checking safety margins for beyond DBE , Installation of seismic instrumentation and incorporation of seismic trip in Dhruva (Trip value will be 80% of OBE),
- Flooding due to Tsunami and storm surge : Plant preprpaednes is adequate for DBFL. But for BDBFL some preparations are on hand

Engine Driven Pumps (EDPs)

- EDP: Station Black Out (SBO)

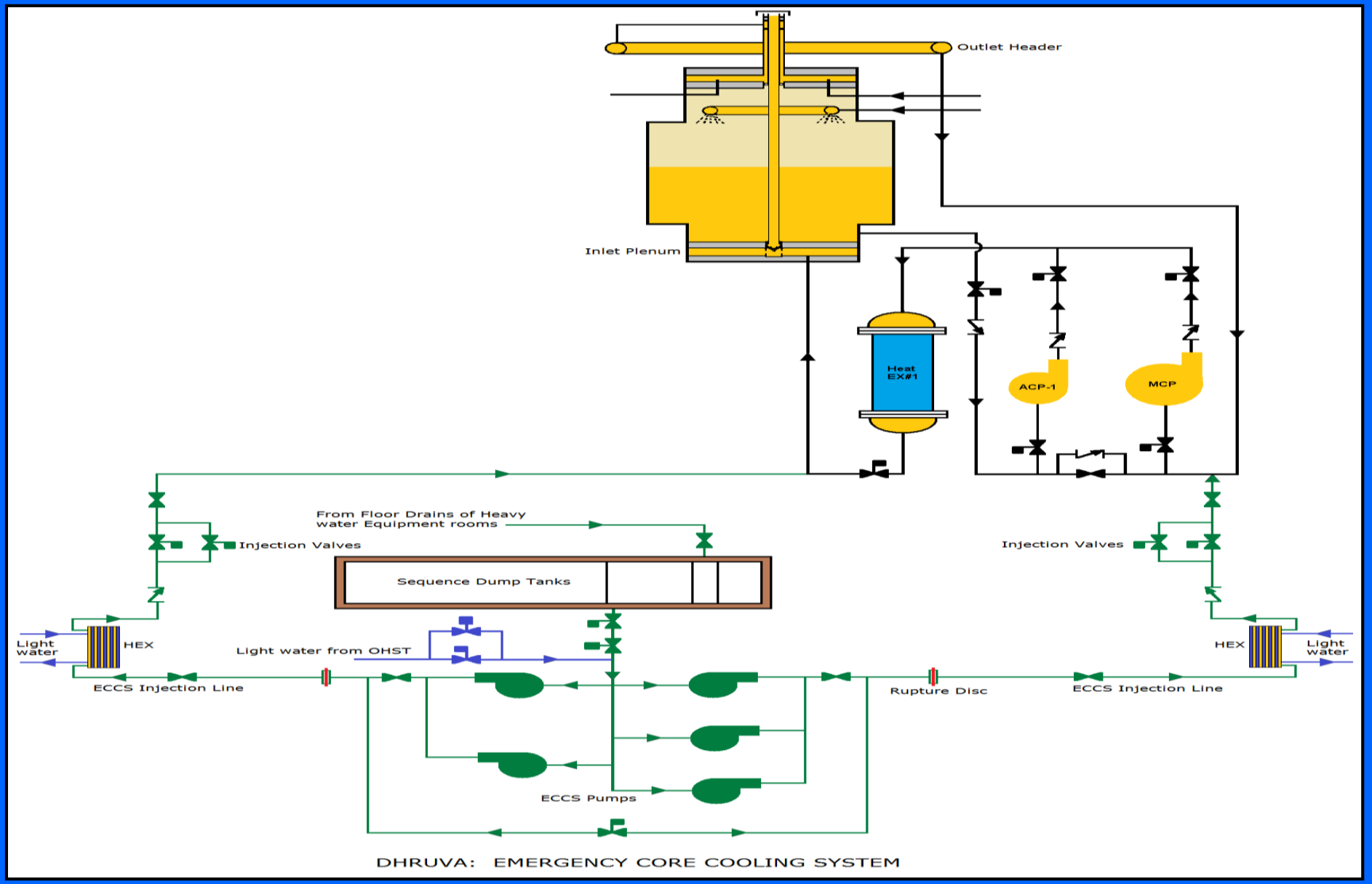


- BDB flood proof pump house to ensure core cooling
- Air cooler DG sets at higher elevation in view of BDBFL
- Hook up points
- Fire hydrant to SFSB

Safety factor# Deterministic safety analysis and PSA

- Deterministic safety analysis
  - LOOP :Flow coast down analysis
  - Compressed air failure
  - LOCA : Dose to public is well within the limit
  - LORA
  - And other PIEs
- Probabilistic Safety Assessment (PSA)
  - PSA level-1: CDF ($4.8 * 10^{-5}$ /year)
  - PSA level-2: containment event tree
    event likelihood ($3.4 * 10^{-6}$ / year)
  - **Reliability analysis of ECCS**
    Unavailability decreased

ECCS modification



Safety factor# radiological protection

- Plant dose normal
- Modification in SFSB purification system
- Plant dose consumption reduced

Safety factor# Human factor

- Plant have adequate qualified staff at all the time
- Licensing procedure , training, refresher training
- Relicensing : After long leave (35 days)
- Man-machine Interface
- Dhruva Simulator to enhance operator confidence

Conclusion

- Based on review as discussed earlier, the plant preparedness and capabilities to perform safe operations within LCOs and actual condition important to safety; **it is concluded that the Plant was operated safely.**
- In view of safety culture adopted by plant ; **plant can be operated safely for coming years without any risk** to members of public , plant personnel and plant

Thank you for attention