भाभा परमाणु अनुसंधान केंद्र
BHABHA ATOMIC RESEARCH CENTRE

Integrated Management Systems in Research Reactors at BARC, Trombay

Vikas Jain

Reactor Operations Division

Reactor Group

Bhabha Atomic Research Centre

Department of Atomic Energy (DAE)

INDIA

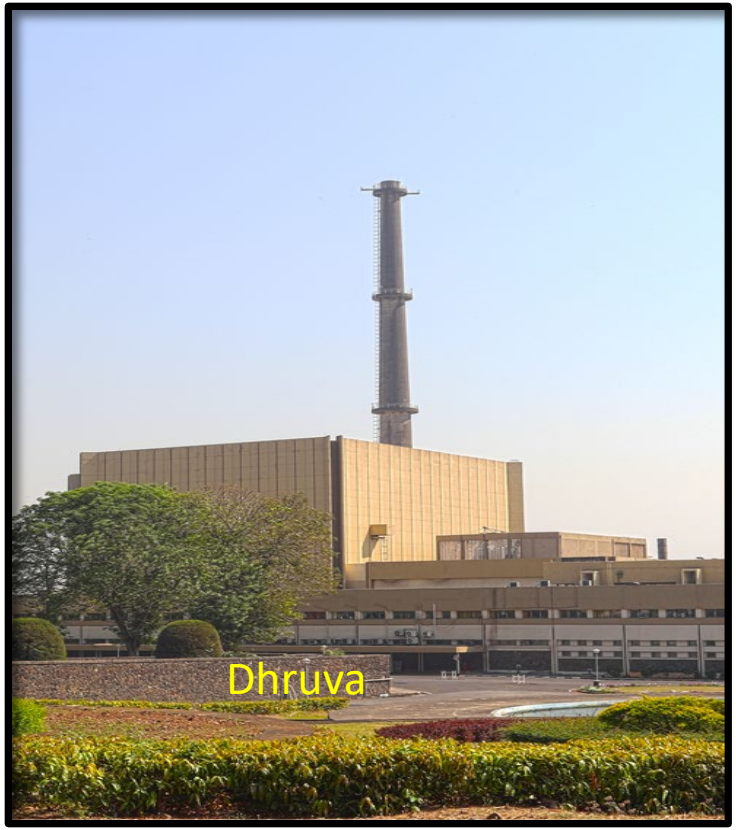
Presentation No S11-04

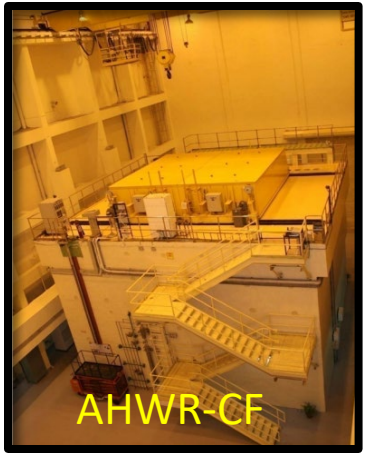
Technical Meeting on Integrated Management Systems for the Sustainable Safe Operation & Effective Utilization of Research Reactors (16-19 June), Mito, Japan

Outline of presentation

- **A Brief introduction to operating RRs** at BARC Trombay Site
- **Management systems** of Research reactors at Trombay site
  - *Mandate*
  - *Functional Groups &Organizational Structure*
  - *Technical Specifications for O & M Activities*
  - *Quality Assurance Programs*
  - *Regulatory interface*
  - *Safety Culture*
  - *Documentation and record keeping*
  - *Engineering change Management*
  - *Measurement, assessment and improvement*
  - *Resource management*
  - *In service inspection program*
  - *Aging Management programs*
- **Conclusion**

Research Reactors at BARC Trombay site





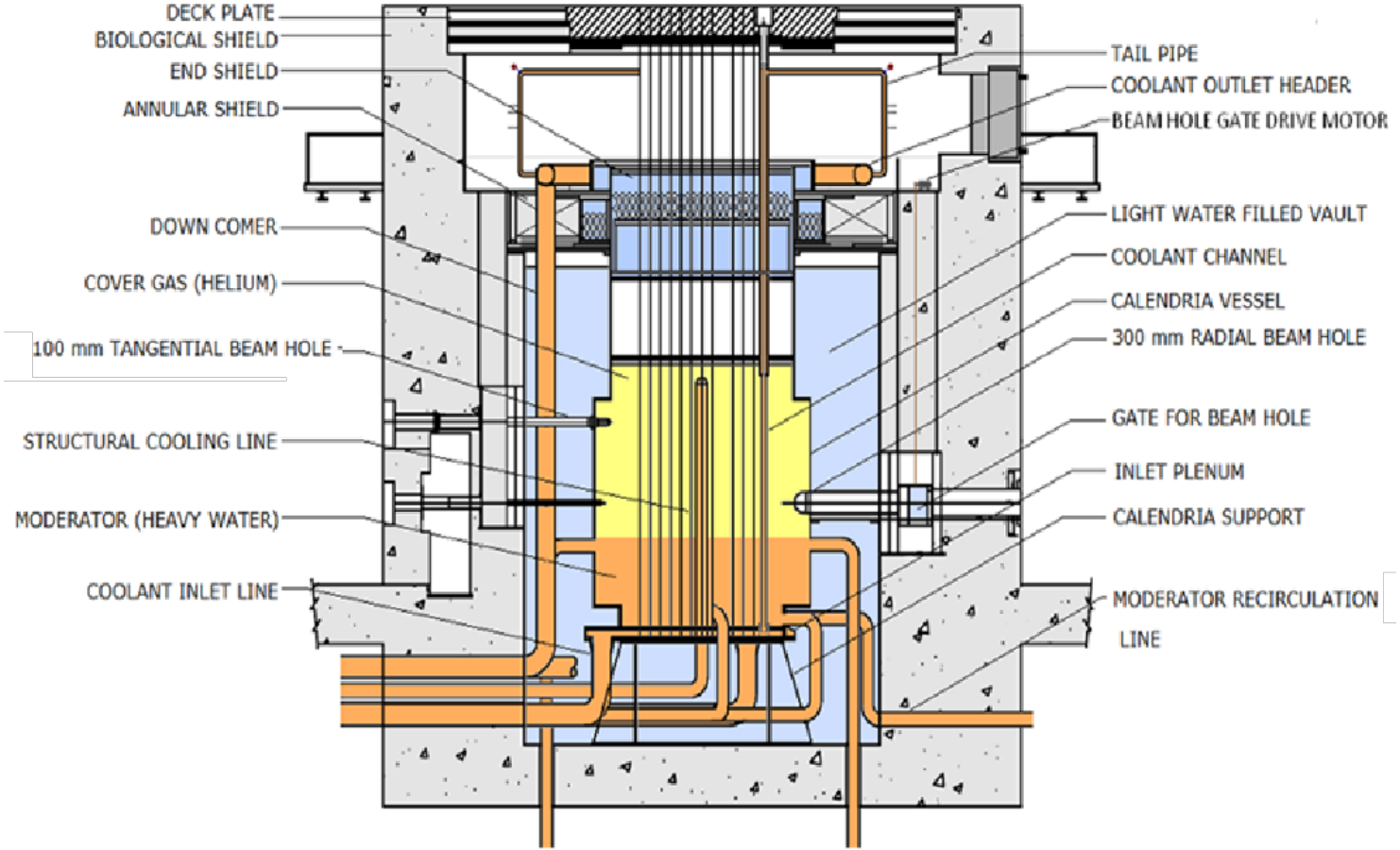
Permanently Shutdown

Dhruva Reactor Hall

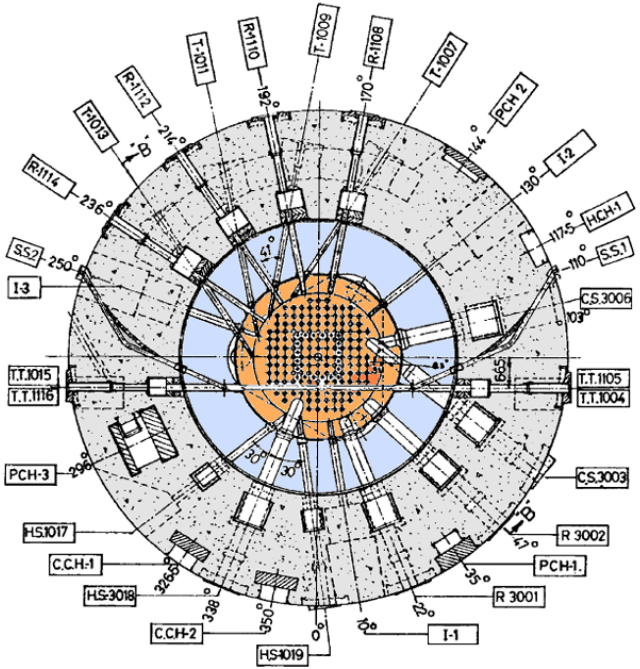
DHRUVA

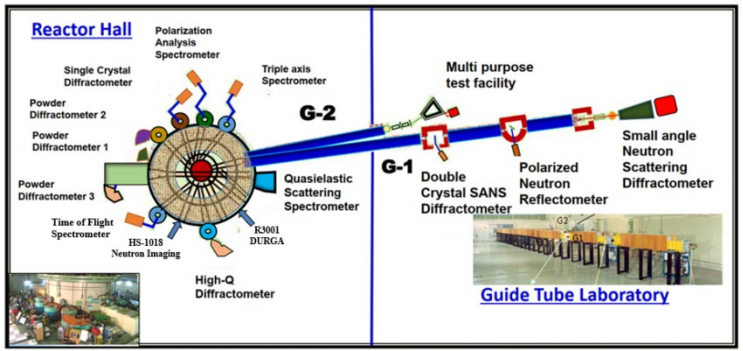
Reactor Type	Vertical Tank Type / Thermal Reactor
Date of Criticality	August 8,1985
Reactor Power $^{(Th)}$	100 MW (Maximum)
Neutron Flux $^{(Max)}$	2.0×10^{14} n/cm^2/sec
Fuel Material	Natural Metallic Uranium
Fuel Element	Pin Shaped with U Pins making a cluster
Fuel Pin Cladding	Aluminium
Core Size	3.72m(D) x 3.87m (H)
Moderator	Heavy water
Coolant	Heavy water
Shut off Rods	Cadmium
Uses	1.Research with beam tube Technology 2.Production of isotopes 3.Material Irradiation 4.Neutron activation analysis 5.Testing of neutron detectors 6.Manpower training

Dhruva Pile Block

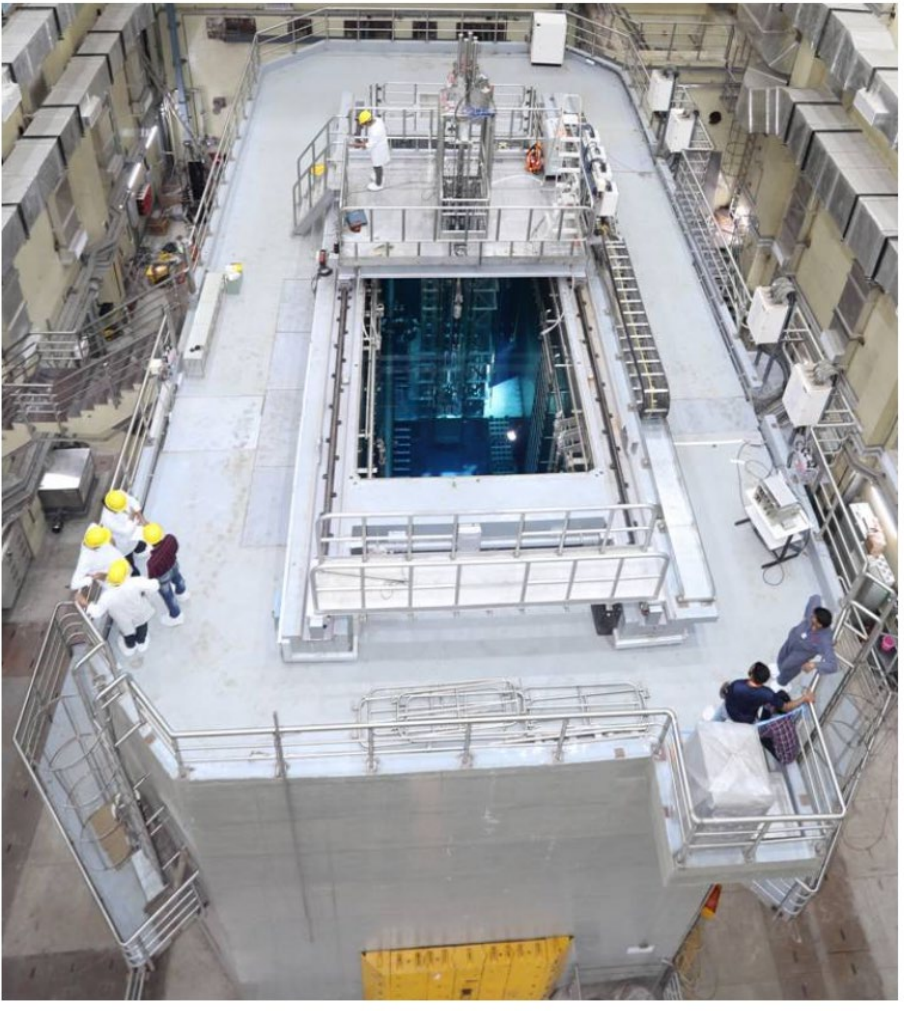


Facilities in Dhruva





- **Neutron Beam Holes**
  - 100mm Tangential and Radial Beam Holes
  - 300 mm dia Beam Holes
  - 100 mm Through Tubes
- **Facilities for Bulk Production radio-isotopes**
  - Isotope carrier rods for Irradiation of Target in standard Al
    - On Power Tray rods for frequent Loading unloading of samples
    - Special Tray rod in Fuel positions for long term irradiation of Target
  - Fission Molly Tray rod for bulk production of Tc-99 with Fission route
  - Slug Rods for Irradiation of Target material of Special Shape and Size
  - Adjuster Rods utilised for Production of Co-60 with High Specific Activity
- **Facility for sample irradiation & Neutron Activation analysis**
  - Pneumatic Carrier Facility---------*Short term irradiation and transient time (Sec)*
  - Self serve Facility ----------*Medium term irradiation (few Hours)*
  - Irradiation in Isotope Tray rods ----*Long term irradiation (Days/months)*
- **In core Testing of Fuel and material for power reactor design**
  - Experimental Assemblies in normal fuel positions.

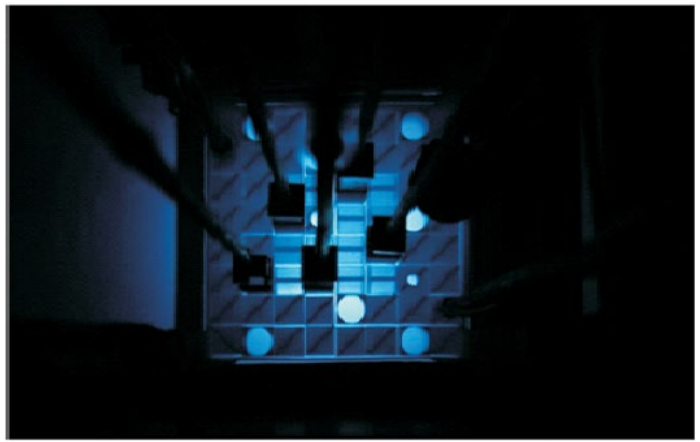


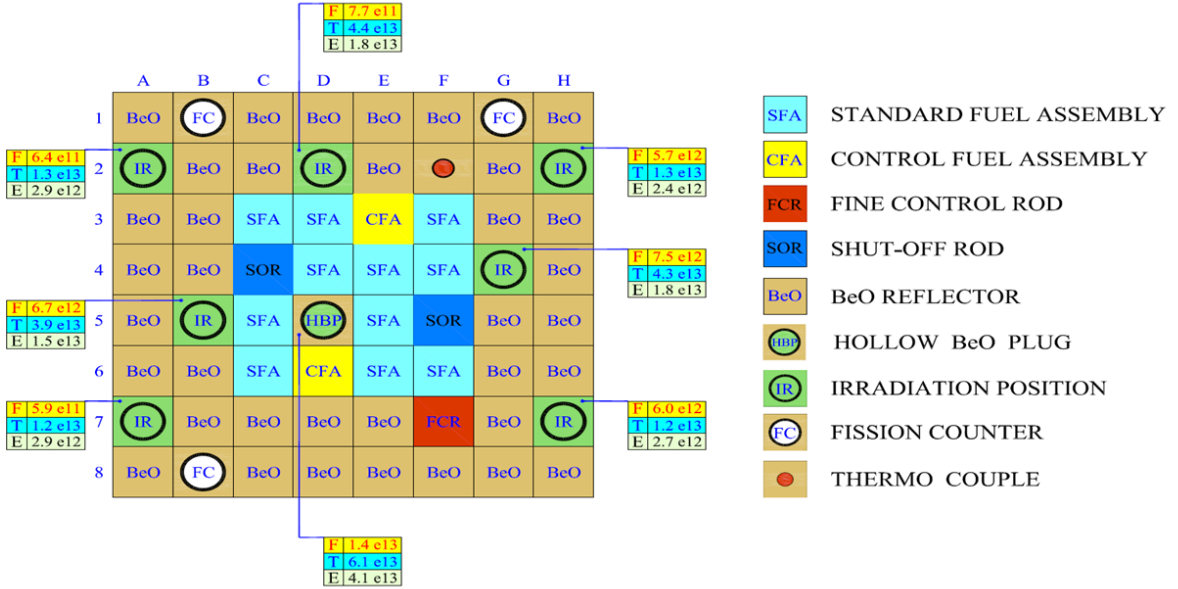
APSARA-U POOL-TOP VIEW FROM VIEWING GALLERY

APSARA-U

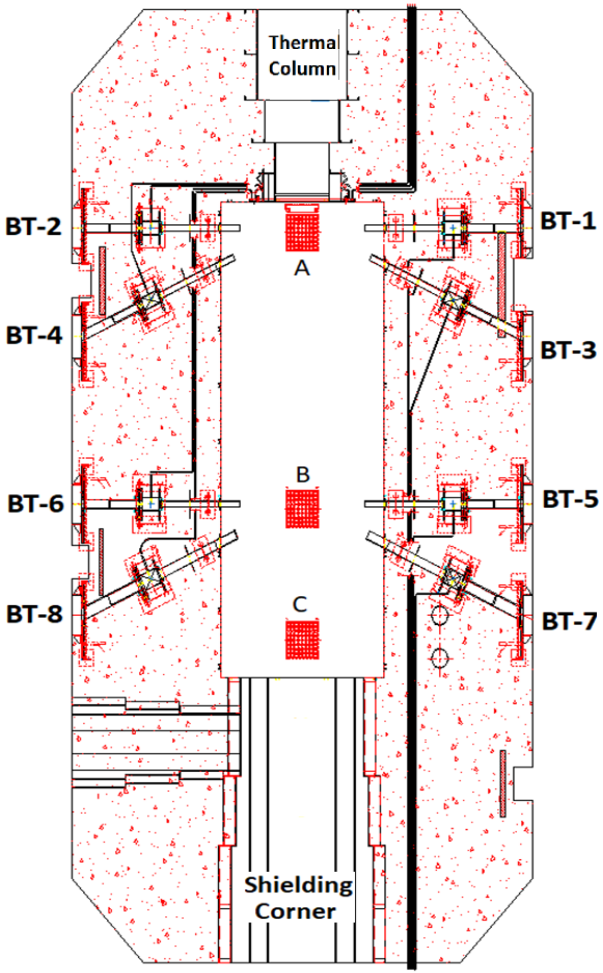
Reactor Type	Pool type/ Thermal Reactor
Date of Criticality	September 10, 2018
Reactor Power (Th)	2 MW (Maximum)
Fuel Material	Uranium Silicide (LEU)
Max Neutron Flux	$6.1X10^{13}$ n/cm^2/sec
Fuel Element	Plates type
Fuel Cladding	Aluminium alloy
Core Size	662 mm x 662 mm x 140 mm; 64 Lettice positions (8 x 8 grid)
Moderator	Light water
Coolant	Light water
Reflector	Beryllium Oxide
Shut off rods / Control Rods	Hafnium
Uses	1.Research with beam tube Technology 2.Production of isotopes 3.Neutron activation analysis 4.Neutron radiography 5.Testing of neutron detectors 6.Shielding experiments

Apsara-U Core





Facilities in Apsara-U



A **versatile** facility with

- **Three different core positions**
- **Easy access to the core**

❑ In-core Irradiation

- ➢ 1 In-core irradiation position
- ➢ 7 irradiation positions in reflector region

Standard Tray Section with loading capacity of 15 standard Al capsules

❑ Shielding corner

- ➢ A Large experimental area for Shielding experiments

❑ Thermal Column

- ➢ 5 Experimental holes in Graphite Blocks.
  - *testing various types of neutron and gamma detectors*
  - *Neutron activation analysis (INAA)*

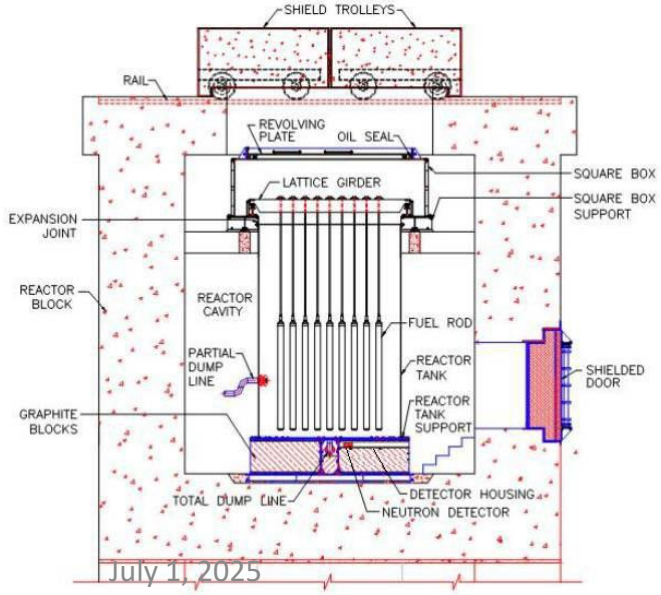
❑ 8 Nos of Beam Tubes

- ➢ Neutron Radiography
- ➢ Neuron scattering experiments
- ➢ National Facility for PGNAA
- ➢ Detector Testing

CRITICAL FACILITY (AHWR-CF)

Reactor Type	**Vertical Tank Type/Thermal Reactor**
Date of Criticality	**April 7, 2008**
Reactor Fission Power (Nom.)	**100 watts**
Neutron Flux (Average)	**~10^8 n/cm^2/sec**
Fuel Material	**Natural Uranium Metal**
Fuel Element	**Clusters of U Pins**
Fuel Cladding	**Aluminium**
Core Size	**3.3 m (D) x 5.0m (H)**
Moderator	**Heavy Water**
Shut Off Rods	**Cadmium**
Uses	1. Validation of the reactor physics design of AHWR 2. Neutron activation analysis 3. Nuclear detector testing Assessment of negative reactivity of absorber material

Features of Critical Facility



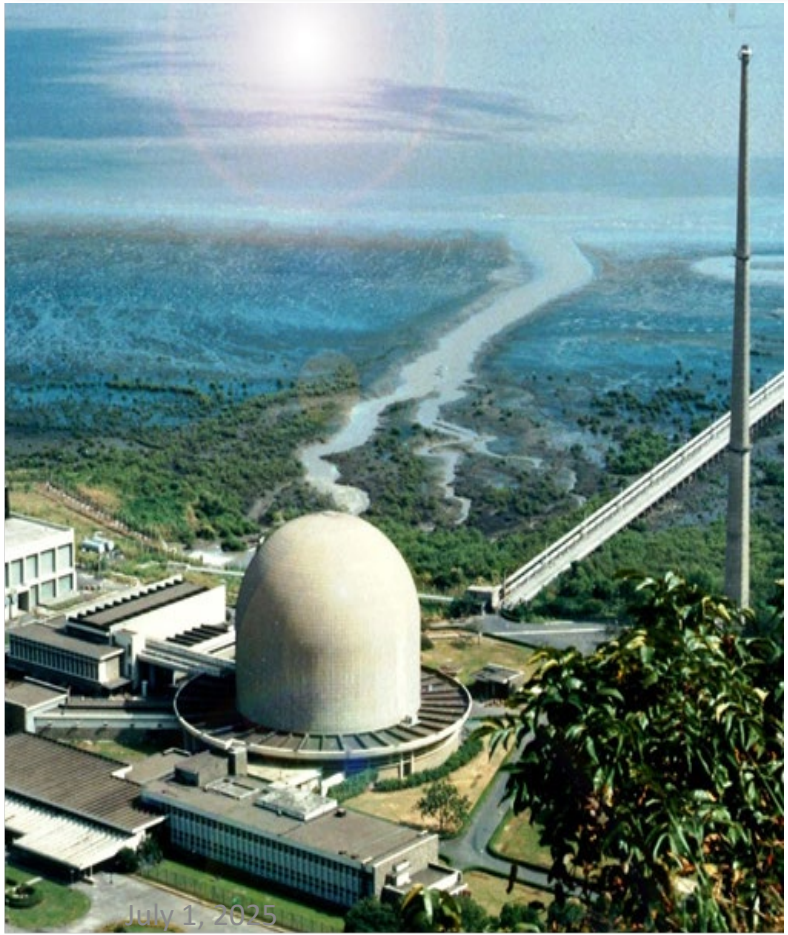
Arrangement for Adjustable grid for Lattice Pitch

- Reactor Physics Study of AHWR fuel of different compositions
  - Critical Height
  - Void Coefficient
- **Reactor Physics code validation**

Large Irradiation space in Graphite Reflector

- Irradiation of **Large and irregular shape objects**
  - **Irradiation of samples for Neutron Activation Analysis**
    - Soil, geological rock, biological sample and metallic alloys
  - Irradiation of special medicine sample
  - R& D and Testing of special Dosimeter Badge
- Testing of neutron detectors

CIRUS (Permanently Shutdown)



Permanently Shut down on 31st Dec 2010.

- **Under Deferred decommissioning state**
  - Reduction of Radiation fields
  - Time to augment Waste handling facilities
  - Simplified infrastructure for dismantling and transport
- **Many of peripheral systems decommissioned**
  - Core & SFSB defueled
  - All fluids like cover gas, moderator and primary coolant removed
  - Process equipment and piping being removed
  - Useful equipment used in other reactors
- **Some of structures and systems being maintained**
  - Civil structure, Material Handling Systems , Ventilation system and power supply system are being maintained
- **Opportunities:**
  - Decommissioning experience of a nuclear reactor
  - Aging Data mining
  - Study of Irradiation Induced Degradation of In-Core Components

Current infrastructure is presently used for setting up of new facilities till Core/pile block decommissioning started.

Research Reactor : Operation

- **BARC** is a Multidisciplinary organization in the field of Nuclear science and technology
- **Reactor Group**, **BARC** as an operating Organisation for research reactors at Trombay site
  - **150 Reactor Years of experience** and Utilisation related to Research Reactors
  - **Quality Management Program** for ensuring safe and sustained operations
- **BARC Safety Council** as regulatory Body

Objectives :

❑ Safe operation of Research Reactors

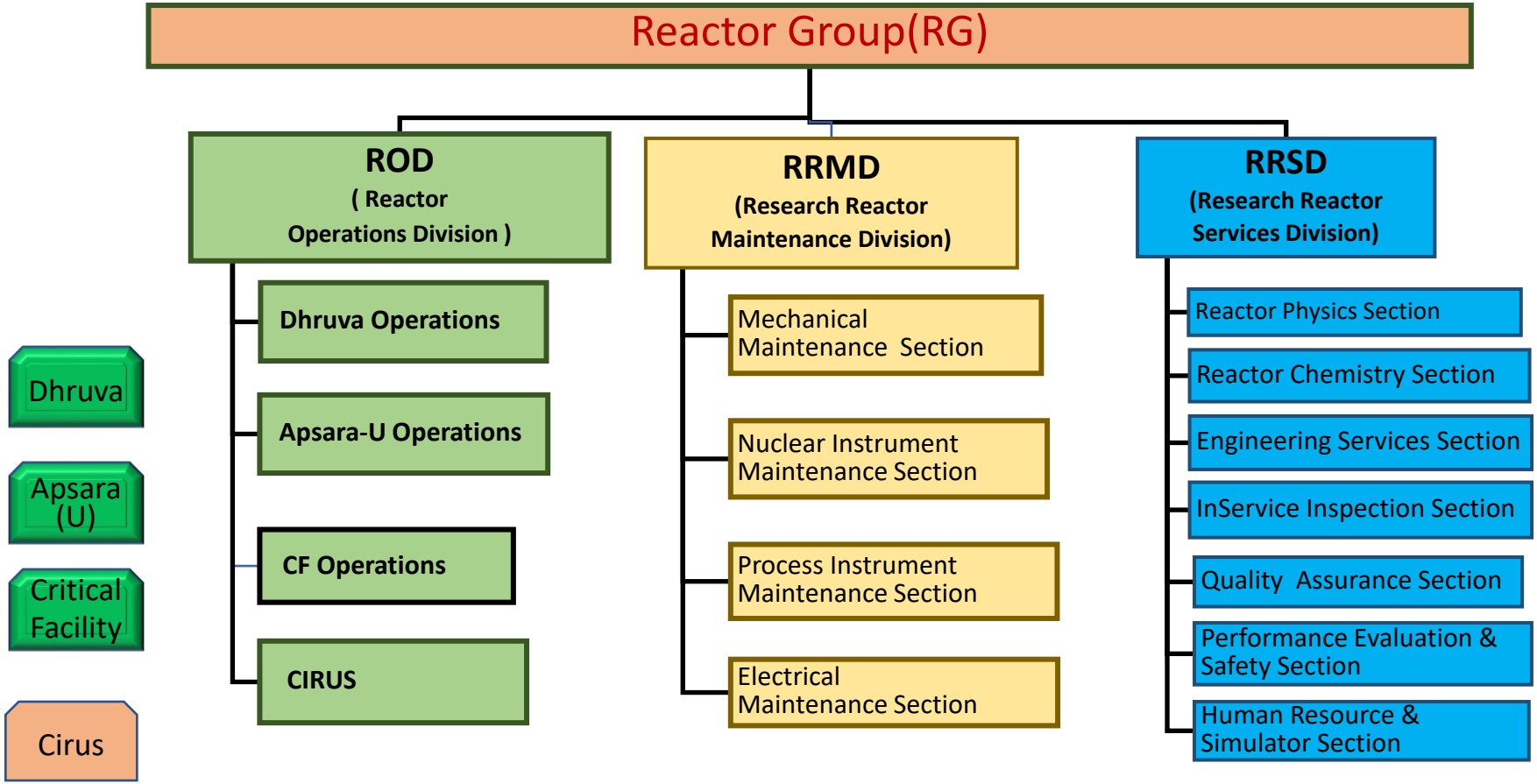
- ➢ O & M of research reactors of BARC, Trombay
- ➢ To ensure Regulatory compliances
- ➢ Safety Up-gradations & Engineering Change Management
- ➢ Aging Management of Old research reactor
- ➢ Ensuring Health & Safety of working Personels
- ➢ Ensuring Safety of Environment due to research reactor operation
- ➢ Ensuring Security of Installations from various threats

❑ Facilitating Utilisation of Research Reactors for

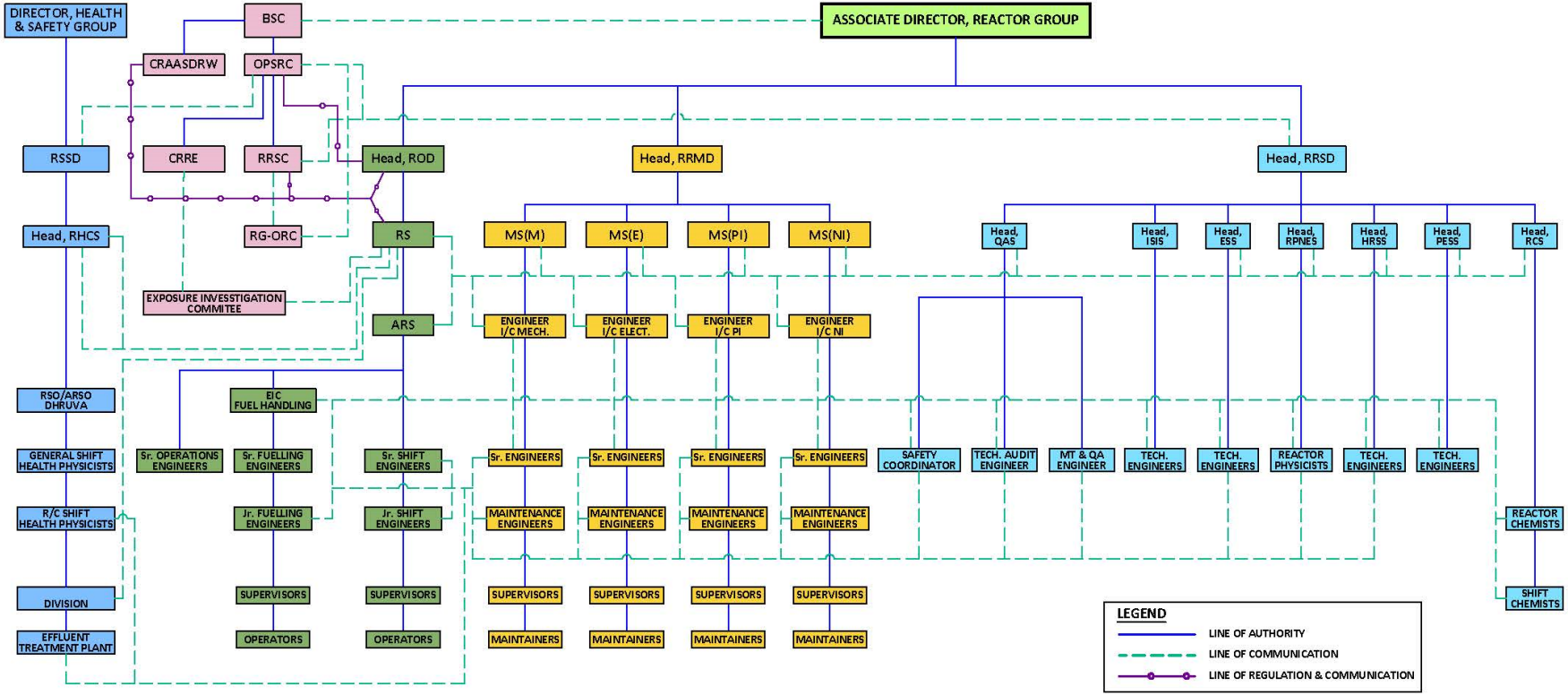
- ➢ Isotope Production
- ➢ Material irradiation for testing
- ➢ Experimental Fuel Testing
- ➢ Engineering Experiments
- ➢ Detector testing
- ➢ Beam Tube research and utilization
- ➢ Neutron Activation Analysis
- ➢ Basic Research in nuclear Science
- ➢ Physics Experiments

❑ Decommissioning of old Research Reactors

Functional Divisions in Reactor Group



Organizational Structure (Reactor Group)



Technical Specifications for Operations

The document can be described as 'basic Law book' for a RR's O&M activities

❑ Limiting Conditions(OLCs)

- ➢ Safety Limits
- ➢ Limiting Safety System Settings (LSSS)
- ➢ Limiting conditions for operation (LCO) on:-
  - ✓ Parameters (Process, Chemical Radiological)
  - ✓ Equipment Availability and Action Level
  - ✓ Minimum Staffing requirements

❑ Surveillance requirements

- ▪ Surveillance Method in O & M practices
- ▪ Surveillance Schedules for safety related components

❑ Administrative controls.

- Organizational Setup
- Licensing & Authorization Requirements for staff
- Plant records and Documentations
- Event reporting
- Functions of safety review committees
- Procedure for Plant Modification
- Renewal of Authorization for Operation
- Radiation Dose Budgeting

Regulatory Interface

"A Multi-Tier Regulatory framework for review and control of RR"

- **Independent Regulatory body for Research reactors**
- **BARC Safety Council (BSC): The Apex body for Regulations in BARC Facilities**
- **Multi Tier review**
  - **Plant Level Safety committee (*PLSC*)----------1st Level**
    Reactor Group-Operations Review Committee
  - **Unit Level Safety Committee (ULSC)----------2nd Level**
    for *Research Reactors Safety review*
  - **Operating Plant Safety Review Committee (OPSRC) -------3rd Level**
    for safety regulations in Operating plants in BARC
- **Expert committees** : CRASSDRW(Waste disposal) , SRC-TRM (transport of active material) for special review in specific subjects

" Final Directive by **BARC Safety Council (BSC)** for regulatory clearances and authorizations"

Quality Management Program for RR

- **All of research Reactors have well defined Quality management program**

- **Our QMP has all functions necessary for IMS**
  - **Management Functions**--- Our organizational arrangement is in place
  - **Performance Functions**---- We ensure Satisfactory performance/conformances with O & M practices
  - **Verification Function**--- Surveillance to identify inadequacies or where possible incipient failures
  - **Corrective Function**-------We ensure corrective actions are being taken in Timely and Prescribed manner

- **Quality Assurance program** is prepared based on guidelines given in
  - AERB Safety Guide No. SG/ QA-5
    "Quality Assurance during Commissioning and Operation of Nuclear Power Plants"
  - IAEA Safety Requirements publication GS-R-3
    "The Management System for Facilities and Activities"

QA Plans in Research Reactors

❑ QA Plans applied to :-

- Operation, Maintenance
- Testing & Inspections
- Modifications
- Experiments, Periodic surveillance Tests
- Reactor core Management
- Process chemistry control
- Radiation protection programs
- Handling & Monitoring of radioactive waste generated etc.
- Checking responses to emergencies
- Activities involving handling of irradiated fuel and other irradiated assemblies
- Design, manufacturing of components and equipment
- Installation and commissioning of equipment and components

QA execution

❑QA is carried out both by

- The personnel who perform the work
- By designated individuals
  - Technical Audit engineer
  - Third Party checks after Major Jobs
- By group of persons
  - Internal Regulatory inspection Team (6 monthly)
  - Regulatory inspection Team by BSC (yearly)

❑ Attributes in our QA Plans

- Surveillance records
- Conformance to Procedures
- Verification of Documentation and Recordkeeping
- Inspections
- Technical audits

❑ Records of QA performed in O & M activities

Area reading sheet and area Logs
Inspection checklists
Procedure Execution checklists
Valve slips
Jumper books
Shift engineer's Logs
Daily summery report of Shift engineers
Work permits and Isolation Tags
Welding permits
Work and test permits
Observation sheets of Maintenance
History Cards
Maintenance Daily report
Records of process system Sampling
Record of radiological Sampling
Surveillance Test reports

Safety Culture – Procedures & Practices

- **Guidelines** for Precautions to be taken for **Industrial safety** and **Radiological Safety.**
- **Duly approved special procedures** for non-routine safety significant activities
- **Approved Emergency Operating Procedures** (EOPs) for postulated off-normal conditions
- **Work permit** system for controlling work flow with appropriate checks in maintenance activities
- **Special work permits** requiring Plant manager approval for special activities.
- **Written valve slips** for effecting valve status changes in process system.
- **Checklists** for routine jobs requiring number of sequential activities such as refuelling
- **Window forms** for routine jobs
- **Periodic mock drills** for radiation emergency, fire and Chemical emergency
- **Reporting of all type of Faults** incidents and Event reporting,
- **prompt reporting** of violation of "Technical Specifications" (within 24 hours) to the regulatory body

These practices have led to the development of a strong safety culture, wherein all plant personnel are conscious about safety, importance of their actions and are proactive about maintaining and enhancing safety.

Documentation

- Important documents being maintained are:-
  - Design Basis reports covering design aspects
  - Safety Analysis Report
  - **Technical Specification**
  - Quality Assurance Plans
  - Design and operating manuals of process systems
  - Drawings for ‘as built’ state of the plant
  - In-Service Inspection Programme
  - Emergency Operating Procedures
  - Radiation and Fire Emergency Procedures
  - Operating & maintenance procedures for normal operation
  - Process & Instrumentation Diagram for all the process and safety systems
  - Master Schedule for maintenance
  - **Commissioning Procedures and Reports**
  - **Recommendations by the Safety Committees and corrective measures taken**

These documents are being reviewed and updated periodically (5 years in most of cases)

Radiation protection Program

A strong, area radiation monitoring program to ensure Minimum dose to plant personals and to environment

- **Annual Dose Budgeting** for a reactor
  - Dose record keeping for plant personals
  - Yearly whole body counting of all workers, Bioassay sampling after special jobs
- **Radiation mapping and sampling schedule**
  - Periodic Radiation serves in all areas of Reactor Complex
  - While working in Radiation areas
  - Waste deposal activities
- **Implementation of ALARA principal's** while
  - Preparing SOPs
  - planning of special activity in Radiation environment
- **Reporting of Non-Conformanace** in Radiation protection
  - Radiation protection violation reports
  - Reporting of over exposure cases.
  - Overexposure investigation committee
    - Investigation level
    - Action Levels
- **Radiation Emergency Preparedness**
  - Plant emergency and Site emergency procedures
  - Drills/dummy exercise for Training and response of individual

Radioactive Waste Management

❑ Practices in Radioactive Waste Discharges

- ➢ No direct discharge of Solid and Liquid waste to environment
- ➢ Gas waste though Stack release after monitoring
- ➢ Record keeping of all types of Wastes.

❑ Regulatory control:

- ➢ **Limits** on Activity, Volume and method of disposal to disposal agency of BARC
- ➢ Licence for waste disposal **for 2 Years**
- ➢ **Special clearance** for Disposal beyond Authorised Limit
- ➢ Documentation of waste disposal data
  - ➢ Monthly basis and being reviewed by Inspection Teams and audit Engineer
  - ➢ Half yearly and yearly disposal data records are being submitted to BSC for their review

Environment Monitoring

- Gaseous discharge from Stack are being sampled.
- Periodic sampling for Radioactivity content in:
  - 24 Ground water bore well sample holes
  - Sea water outfall sampling
  - Radioactivity in Soil, Vegetation growth around in our complex
- Trends of such Radio activities in Environments are being:
  - Monitored
  - Recorded
  - Reviewed by Regulators
- General radiation level monitoring in the Facility

Performance measurement & Assessment

❑ Attributes for Performance Measurement

- Routine monitoring and surveillance schedules
- Technical reports of different sections
- Incident Reports

❑ Assessment by individual and Plant Management

- Evaluation of known performance issues by respective section and PLSC
- Identification of contributing management /technical aspects to Fix the issue
- Improvement being done based on self assessments

❑ Independent Assessment

- Audits
  - Quarterly Internal Audits of O & M activities by QA section
  - Internal regulatory Inspection by a team constituted with in Reactor Group(half yearly)
  - Regulatory Inspection by regulator (every year)
- Monthly reports of operations are being Sent to Regulators for review
- **Periodic Safety Review (PSR)**
  - Relicensing by Regulatory body after Safety Assessment PSRs

Periodic Safety-Review (PSR)

❑ Five/Ten year Operational data safety indicators

- Reactor performance
- Maintenance records of safety systems,
- Radiological safety data
- Events history of safety system malfunction
- Radiological waste disposal data
- Licensed Manpower
- **Comparison with Current Quality standards.**

❑ PSR is submitted to regulatory Body

- Thorough review of this document by regulators.
- The regulators ensures:
  - Plant has operated safely and
  - All measures to maintain safe operation in future .

➢ **Based on PSR, BSC grant the license for 5 Years for Operations**

Event Reporting

"Graded approach for reporting and reviewing Events"

❑ Fault Reports

- ➢ **Equipment Faults,**
- ➢ **Reactor Unavailability due to some Fault**

- No Safety significance However corrective action required
  - to avoid translation of precursors into events/significant events
- For repetitive Faults: Modifications

❑ Radiation Protection Violation Reports.

- Procedural violation of Radiation protection

❑ Reporting of Over Exposure cases

- Investigation by special committee(CRRE)
  - Review of condition or Violation of procedures leading to over exposure
  - Isolation of exposed personals from radiation area for a definite time
- Reports reviewed by PLSC

❑ Injury on Duty Reports.

- Reviewed by Health Safety Section of BARC and by PLSC

Event Reporting (cont..)

❑ Event Reports(ER)

- Lower safety significance i.e., with limited consequences from safety point of view
- Defined criteria and prescribed format for reporting (to be reorted with in 30 Days)
- Finding and recommendations are Submitted to higher level committee i.e. PLSC

❑ Significant Event Reports(SER)

- Higher safety significance. Prompt notification to the Regulators
- Reviews by all safety committees i.e. PLSC, ULSC and OPSRC
- For many cases reactor is kept shutdown until clearance from Safety Committees
- Root Cause Analysis and Event Closure Notification Reports

Corrective and Preventive Actions:-

- Education of Plant personals about root cause, consequences and Action taken with Crew meeting, Special Lectures and Additional Guidelines)
- Modification in certain cases
- History of all Events is being updated in Operating Manuals of Dhruva for general education
- New Guidelines and Revised Operating Procedures

Engineering Change Management

- **Major and Safety related modifications:**
  - Review by PLSC and then by ULSC and sometimes by OPSRC also
- **Minor modifications important to safety:**
  - Reviewed by PLSC only
- **Modifications not having impact on safety:**
  - Predefined modification proposal processing route.
  - Review by in charge of respective functional group, Heads of Divisions
  - W/O issued to maintenance agencies after review for implimentaton
- **Configurational management after implementation of modifications:**
  - Issuing of Technical note of completion
  - Updating exiting drawing and Manuals.
  - Revision of Operating Guidelines and SOPs if required

Training, Licensing and Re-Licensing

- **Formal training and licensing of all operating personnel**
- **Structured training programme:**
  - Class room lectures by senior and well qualified O & M staff members
  - On-the-job training in different plant areas
  - Systems checklists (a set of questions) signed by the authorized personnel.
- **Qualification and authorisation Requirements:**
  - Written examination
  - Walk-through test
  - Assessment interview by an expert committee.
  - Authorisation by respective Plant Superintendents to work on licensed position.
- **Reauthorization and Re- Licencing :**
  - The license is **valid for three years** after which the person needs to be re-licensed by the expert committee.
  - In case a person remains **absent from his licensed position for more than 35 days**, he/she is required to get re-certified as per the established procedure before resuming his licensed position.

In-service inspection program

Approved In-Service Inspection programme for Health Assessment of SSCs

- **10 Year inspection cycle for critical components and structures**
- **NDT Techniques** with predefined Level of inspection
- **Condition monitoring** of roto-dynamic equipments
  - Early Prediction of defects developed
- **Special inspections** of systems, structures and components (SSCs)

The mandate is achieved by using various Non-Destructive Testing techniques as per Codel requirement.

Aging Management program

➢ RG Experience:

- Aging management of reactors like **CIRUS & APSARA**
- Now Aging Management program was formulated for Life extension of Old reactor like **Dhruva**

➢ Attributes for formulation of Ageing Management Programme:

- **Master list of SSCs and classification**
  - Major critical SSCs Limiting plant life
  - Critical SSCs.
  - Important SSC
  - Other SSCs.
- **Non-Replaceable** & **Non-Isolatable** components
- **Requirement of Core unloading and Long outage** of reactor for repair/replacement
- **Periodic Safety review of the reactor** to establish the actual status of SSCs including inspection
- **potential refurbishment needs** by considering operation feedback
- **preliminary evaluation** and relevant ageing mechanisms
- **Strategic planning to ensure** for implementation of program ensuring minium reactor unavailability.

This will enhance the operating life of Dhruva reactor by another 20-25 years

Electronic Database Management System

- Reactor Group Document management Systems(RGDBMS):
  - **Electronic database management system**
  - **Dedicated servers** to upload technical documents by Authorised personals only
  - Mandatory documents uploaded
  - all technical Reports are being submitted
  - MoMs of Safety committees
  - **Modification Proposal review and feedback through RGDBMS**
  - Access to Authorised persons/groups

Record Keeping

- **Records of Operational/maintenance/ technical supports**
  - maintained in Control room/ Library/ record room/ associate sections:-
- **Permanent records as per the approved list**
  - maintained in retrieval form for future reference
- **Daily reading sheets, inspection Checklists, work permit etc.**
  - **destroyed after 2 years of retention**, after ensuring:-
    - ✓ *Annual performance assessment of all systems has been done*
    - ✓ *Suitable in-service inspection reports are issued.*
    - ✓ *A representative samples has been preserved for record*
- **Electronic data from recorders of Plant process parameters**
  - Being saved over a secured server periodically.

Resource Management

❑ Manpower Management

- ➢ Recruitment though central government process
- ➢ A defined system of Manpower training , Licensing and Authorization

❑ Financial Management

- ➢ Government funded organization with Fund allocation for R & D activities with strict rules for purchase

❑ Material Management

- ➢ Centralized store for BARC facilities supplying consumables regularly to Zonal stores
- ➢ RG-zonal store for keeping stock and inventory of materials records of storing slow or fast moving items
- ➢ QA in Procurement and inspection
- ➢ Process of procurement, required authorization level has been clearly defined based on Cost.

❑ Infrastructure Management

- ➢ Building confining safety related equipments:
  - ❑ In-service inspection with NDT techniques to check their healthiness
  - ❑ Up-keeping of Civil structure, Prompt repairs as per requirement
- ➢ Ensure safe environment for O & M as well as research activities

Conclusion

- Our Research reactors have:-
  - Quality Management Systems are inline with IAEA Safety standards.
  - A structured organisational setup
  - Evolved QA plans to ensured application of Safety in all Processes
  - Well-defined system for Reporting, Operational Feedback and Performance Review
- Scope of improvement
  - Classification of information and documentation based on their level (3 Level defined in item 2.52 and 2.62 in IAEA GS-G-3.1)

Thank You

for listening with Patience

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  - Well-defined system for Reporting, Operational Feedback and Performance Review
- Scope of improvement
  - Classification of information and documentation based on their level (3 Level defined in item 2.52 and 2.62 in IAEA GS-G-3.1)