

PHWR SAFETY REVIEW EXPERIENCE

CONSENTING PROCESS

FOR

PRESSURISED HEAVY WATER REACTORs

R.I. Gujrathi, S.A. Bharadwaj



TOPICS

General

Regulatory Consenting Process

Aspects Related to Consenting Process

Regulatory Inspection

Enforcement Actions

Concluding Remarks



GENERAL

- In the initial years of Indian Nuclear Power Program in mid-fifties, Research Reactors were under construction/ commissioned.
- **Formal consenting procedures were not fully established.**
- Safety assessment involved essentially self-assessment and direct discussion with the designers.
- **This review concept was a speedy way of safety review and implementation of decisions.**



GENERAL

- **Our first twin-unit PHWR station, RAPS-1&2, based on Canadian design, was built in seventies. A safety committee reporting to the Secretary of Department of Atomic Energy reviewed the safety aspects of these units.**
- **Subsequently, a high level committee, DAE-SRC, was constituted to ensure the safety of projects as also of the operating plants. Two-tier safety review was established for MAPS-1&2 and systematic and detailed review was carried out under the aegis of DAE-SRC.**
- **In case of MAPS-1&2, review was essentially limited to commissioning stage**



GENERAL

- Need of more systematic, comprehensive, & in-depth review and safety assessment became felt as number and capacity of various types of nuclear facilities increased over the years.
- Atomic Energy Regulatory Board (AERB) was formed in the year 1983 with the powers to lay down Rules and Regulations for Enforcing Regulatory and Safety Requirements



NARORA DESIGN SAFETY REVIEW

- **NAPS-1&2: Third PHWR based station – Narora**
- **Narora Units - Indigenous Design, Improved safety Features**
- **Design Safety Review Committee was constituted in mid-seventies, the committee subsequently was made part of DAE-SRC and finally became part of AERB. In-depth review of the project started in mid-eighties after formation of AERB.**
- **Design Safety Review of Narora Project has taken place concurrently with evolution of detailed design and construction.**



NARORA DESIGN SAFETY REVIEW

- **No Precedent of Design Safety Review Process**
- **Three-tier review: NDSC? ACPSR? AERB BOARD**
- **SSCs - Detailed Review - Working Groups**
- **Expertise from DAE (mainly BARC, NPCIL) and NON-DAE Organizations (Academic Institutes and Retired DAE-Officers)**
- **The review approach adopted has become 'Reference review for Future Projects'**



MAJOR DOCUMENTS/ GUIDELINES USED FOR REVIEW

- Philosophy and Principles enlisted In IAEA Codes and Guides, (Many of which were evolving during the period)
- **Safety Philosophy and Safety Systems of Canadian Plants**
- USNRC Documents, as applicable
- **Feedback from TMI-2 Accident in 1979**
- Basic documents reviewed: Design Basis Reports, Design Manuals, Safety Analysis Report, Design Notes and Technical responses from the Utility



Codes and Guides

AERB developed a series of Codes & Guides to lay down the Regulatory and Safety Requirements for NPPs.

All the Codes and most of the Guides are published.

- ❖ **Regulation of Nuclear and Radiation Facilities,**
- ❖ **Siting,**
- ❖ **Design,**
- ❖ **QA,**
- ❖ **Commissioning and Operation**
- ❖ **Decommissioning**



MAJOR CONSENTING STAGES

As per the Code on “Regulation of Nuclear and Radiation Facilities”, Specified Consenting stages for NPPs and Research Reactors are:

- **Siting**
- **Construction**
- **Commissioning**
- **Operation**
- **Decommissioning**



GUIDANCE ON CONSENTING PROCESS

AERB Guide on Consenting Process for NPPs and Research Reactors, “AERB/SG/G-1” (draft). The guide covers the following:

- **Contents and Format of safety documents such as Site Evaluation Report, Safety Analysis Report**
- **Lead-Time for submission of documents**
- **Review areas for each stage of consent**
- **Method for review and assessment**
- **Application-Formats for seeking various consents by the utility. (AERB/SG/G-7)**

General information regarding contents of many other documents need to be submitted by applicant is made available in AERB Guides and Manuals.



Siting

Site Selection by DAE Committee

Review by SEC of AERB

Review Areas: Those related to the site and environmental conditions and aspects, which will influence the design basis of the NPPs, namely:

- ✓ Geological data
- ✓ Topography
- ✓ Hydrology and hydro-geology
- ✓ Meteorological data
- ✓ Natural phenomena such as earthquakes, floods and tornadoes
- ✓ Potential external man-induced events such as plane crashes, fires and explosions
- ✓ Failure of man-made structures such as dams



Siting: Review Areas...

❖ **Those related to the effects of the plant on the environment that could warrant specific design and operational requirements, namely:**

- Dispersion of radioactive liquid effluents
- Dispersion of radioactive gaseous effluents
- Radiation exposure of the public arising from liquid and gaseous radioactive effluents released during normal operation, AOO and AC taking into account dispersion patterns, population distribution, public water supply, milk and food consumption, etc.
- Availability of water for process cooling and other requirements



Siting: Review Areas...

- ❖ **Availability of Infrastructural Facilities for emergency response purposes.**
- ❖ **Security measures with reference to Site Characteristics**



Siting: Documentation Requirements

This requires on the part of the applicant, submission of

❖ Site Evaluation Report and

❖ Design Basis Information report



Design Basis Information report

Content:

- Brief Description of the project
- General design Criteria
- Safety objectives and principles
- Plant layout and adjoining facilities
- Scheme of safety and seismic classifications
- Applicable Codes, Standards and Guides
- Brief description of plant systems
- Waste management, Environmental monitoring
- Emergency preparedness



CONSENT FOR CONSTRUCTION

Construction is second step of consenting process and at this stage, varieties of project related aspects are addressed by the applicant and these reviewed in-depth by the safety committees.

Review Areas:

General design considerations

- ✓ **Safety Principles : defense in depth, redundancy, physical separation, diversity, etc.**
- ✓ **Safety importance given to accident prevention, surveillance and means of accident intervention and mitigation**
- ✓ **Safety classification of SSCs.**
- ✓ **DBGM, geo-technical investigations, meteorological parameter**
- ✓ **Layout of plant buildings and equipment, physical separation, easy accessibility for maintenance and surveillance, radiation shielding, missiles, fire, other natural & man-induced events.**



CONSTRUCTION: REVIEW AREAS...

Building and Structures

- ✓ Functional and safety requirements of radioactivity confinement structures.
- ✓ Seismic design.
- ✓ Loads and load combinations.
- ✓ Construction, Maintenance and ISI aspects
- ✓ Fire and missile protection
- ✓ Radiation Zoning aspects
- ✓ Decommissioning aspects.
- ✓ Identification of vital areas of the plant is essential. Review of the provisions of physical protection system is carried out in-detail.

CONSTRUCTION: REVIEW AREAS...

Reactor systems:

- ✓ Reactor core and cooling systems, reactivity control systems, spatial power distributions, Re-fuelling mechanisms
- ✓ Fissile material storage, handling, sub-criticality margins
- ✓ Active coolant systems
- ✓ I&C, MCR and SCR design
- ✓ Elect. Systems, emergency power supply
- ✓ Plant auxiliaries and ventilation
- ✓ Radioactive effluents, waste management



CONSTRUCTION: REVIEW AREAS...

Safety systems and other protection features

- ✓ **Protection systems and safety actuation systems**
- ✓ **Engineered Safety Features**
- ✓ **Radiation protection**
- ✓ **Fire protection systems**
- ✓ **Protection against chemical hazards**



CONSTRUCTION: REVIEW AREAS...

Safety Analyses

- ✓ **Analyses of safety during normal operation including estimates of radioactive effluent releases to the environment.**
- ✓ **Analyses for assessing radiological impact due to release of radioactive substances to the environment during anticipated operational occurrences and postulated accident conditions.**



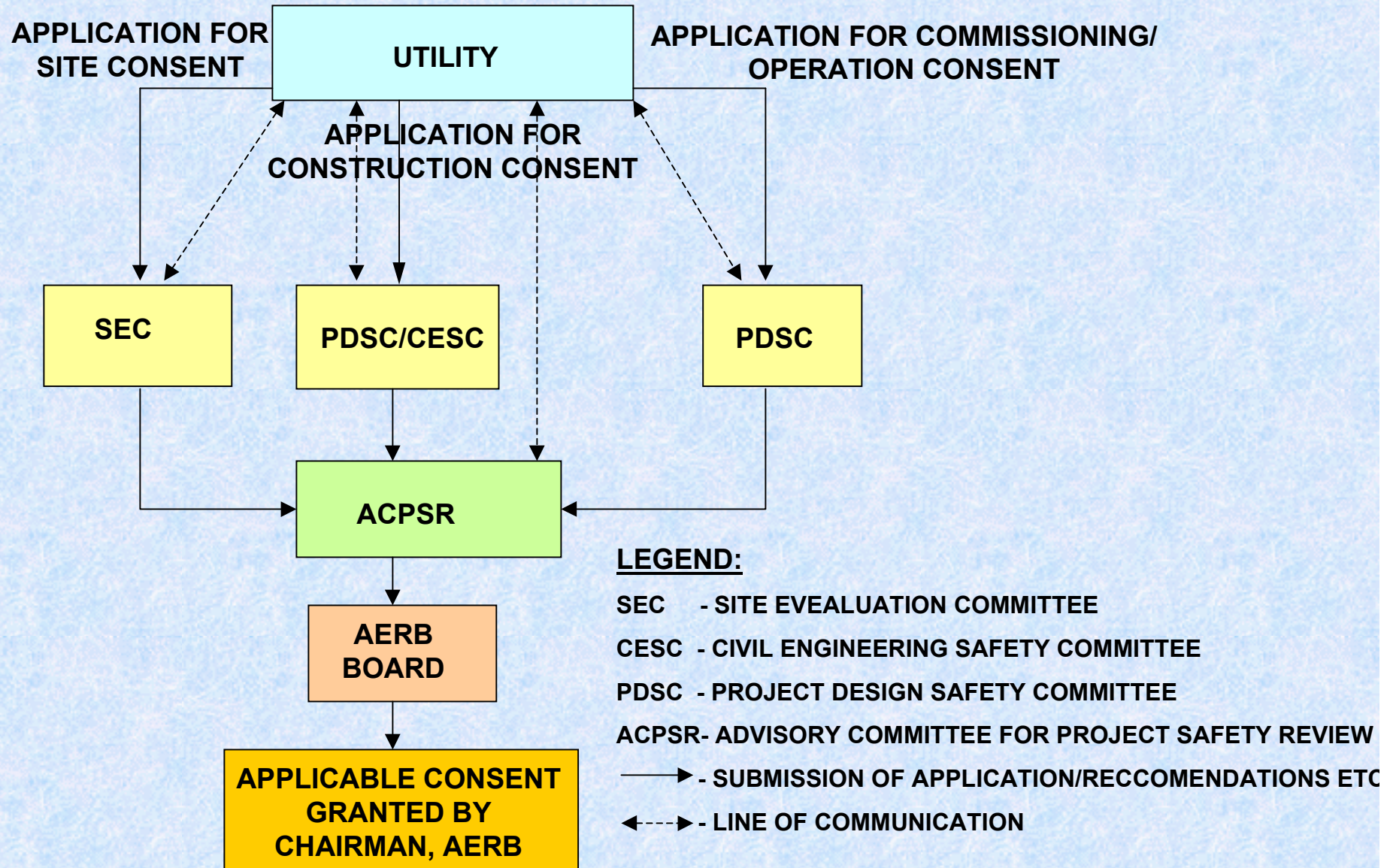
CONSTRUCTION: REVIEW AREAS ...

Other Aspects:

- ✓ Quality assurance program for design & construction stages including for vendors
- ✓ **Maintenance and maintainability aspects**
- ✓ Provision for industrial safety including for contractor workers
- ✓ **Provision for In-service Inspection.**
- ✓ **Basic Scheme for Decommissioning of the Facility**



THREE TIER CONSENTING PROCESS FOR PHWRs



Stage-Wise Consent for Construction

Consent for construction is given in one stage or in three sub-stages, if required so by the utility. Three sub-stages are:

- **Sub- Stage 1: Clearance for Site Excavation:**

Clearance for ground excavation for laying foundations of buildings/ structures of main plant area.

- **Sub- stage 2: Clearance for First Pour of Concrete (FPC):**

This is a clearance for pouring of structural concrete for foundations of the main buildings/structures. **Normally, starting of concrete pour for Reactor Building Raft is considered as Clearance stage.**



Stage-Wise Consent for Construction

- **Sub- stage 3: Clearance for Erection of Major Equipment -**

This implies clearance for complete construction including erection of all equipment.

- **For the 4 units of PHWRs presently under construction, Kaiga-3 & 4 and RAPP-5 & 6, construction clearance has been granted in 3 sub-stages.**



CONSTRUCTION: DOCUMENTATION REQUIREMENTS

- ✓ **PSAR: Design Description**
- ✓ **PSAR: Accident Analysis**
- ✓ **QA Aspects related to Construction and Equipment Erection**
- ✓ **Construction Schedule**
- ✓ **Feedback from operating experience especially from similar type of plants**
- ✓ **Design Basis Reports and Design Notes as supporting documents etc.**

If consent is to be accorded in 2 or more sub-stages, review of the above documents is to be organized, accordingly



COMMISSIONING

For the purpose of regulatory review, commissioning activities of PHWRs have been grouped in 3 phases and 8 sub-phases, these are:

Phase A:

- **PHT System Hot conditioning and light water Commissioning**
- **Fuel Loading, Moderator System Flushing with Limited Amount of Borated heavy water**
- **Bulk Addition of heavy water to PHTS**
- **Bulk Addition of Borated heavy water to Moderator System**



COMMISSIONING SUB - PHASES

Phase B:

- ❖ First Approach to Criticality
- ❖ Low Power Physics Tests

Phase C:

- ❖ Systems Performance Tests at Power Level: 50 and 90%
- ❖ Systems Performance Tests at Rated Power Level

A total of 8 sub-phases are identified for commissioning consent, for each of these sub-phases three tier review is not required. One/Two/ Three tier review has been required depending upon the safety significance of the sub-phase. For example, three tier review is essential prior to granting consent for 'First approach to Criticality'.



ADDITIONAL REVIEW GROUPS

Additional Review-Groups are constituted, prior to start of Commissioning Phase, especially for followings:

- **Commissioning Review**
 - **Containment Test Procedures [Proof Test, ILRT and other Tests]**
 - **Technical Specifications for Operation**



WITNESSING OF COMMISSIONING TESTS

AERB Representatives/ Experts are present as 'Observers' during conduct of following Tests:

- ✓ **Containment Tests (Proof Test, ILRT)**
- ✓ **Tests related to Emergency Power Supplies**
- ✓ **Hot Conditioning of Primary Heat Transport System**
- ✓ **Testing of Emergency Core Cooling System**
- ✓ **Tests related to shut-down systems**
- ✓ **First Approach to Reactor Criticality**
- ✓ **PHASE-B tests for measurements of physics parameters**
- ✓ **PHASE-C - Transients**



COMMISSIONING PROCEDURES AND TEST- RESULTS

REVIEW METHODOLOGY:

- All the commissioning procedures for testing of safety systems are first reviewed and accepted by the designers. Then these are reviewed by safety committees.
- The observations made and results of the commissioning tests are first reviewed in-house by the respective designers to verify that design intents are met.
- The designers review reports indicating deviations, if any, along with bases for acceptance are forwarded to safety committees for independent and integrated review of system performance during commissioning tests.

Occurrence of any Safety significant event during the course of commissioning is reported to safety committee for review and changes/ modifications in the system are carried out with the consent of safety committees



Commissioning: Review areas

- **Schedule of Commissioning programme**
- **Structure of ,Responsible Organization and Organization for Operation and Commissioning**
- **QA manual for commissioning and operation**
- **Training and qualification programme**
- **Technical Specification for Operation**
- **ISI manual**
- **Radiation Protection procedure**
- **Physical Protection System**
- **Emergency Preparedness Plan**



Availability of Documents

Following documents are to be made available to Regulatory Body, when asked for review. Normally, these are checked on sample basis for verification of information, proper maintenance of records etc.

- **Final as built design of the plant systems and components**
- **Quality records (CCCs, STDs, EHDs etc.)**
- **Pre-Service Inspection reports/records**
- **Organization and records of qualification of the O & M personnel**
- **Operating instructions, commissioning and operating procedures. Emergency Operating Procedures.**
- **Updated design manuals, maintenance manuals and training manuals**
- **Fire Order and related provisions**



Consent for Continuous Operation

Documentation Requirement:

- **FSAR reflecting as built design cleared by the Regulatory Body**
- **System Performance Reports on 100 days of operation at rated power**
- **Status and Measures to resolve pending issues**

**Authorisation for continuous operation is issued
- for a period of three years**



LEAD TIME FOR SUBMISSION OF DOCUMENTS

- The applicant should present, to start with their schedule of the project and plan for the submission of documents.
- Advance availability time-period required for review of the various documents has been indicated in the Guide, AERB/SG/G-1. In some cases, lead time is decided **“Mutually between the Applicant and Regulatory Body”**.
- Lead time determination for submissions is done considering the project schedule.



SCOPE AND DEPTH OF REVIEW

- Scope and depth of review of the project depends upon several factors such as design safety features including novel features, complexity of processes involved, experience with similar plants of the applicant etc.
- **Projects of Repeat Design** - In-depth safety review of design of certain/many systems may not be necessary, as it has been carried out for plants of same design and capacity. However, differences in comparison to earlier plants need to be looked into.
- **Nevertheless, it is essential that review of commissioning stage is carried out in-detail for repeat design also.**

REGULATORY INSPECTION

Routine Regulatory Inspections (RI) of projects are conducted to ascertain that the Applicant is complying with the regulatory stipulations in practice,.

Aspects covered normally during RI of projects are:

- **Site inspection and evaluation of data submitted by the applicant**
- **Verification of compliance with conditions of construction consent**
- **Ensuring effective implementation of QA/ISI programme**
- **Industrial and Fire Safety aspects**
- **Observing/witnessing of conduct of certain pre-identified important tests and reviewing the results.**



REGULATORY INSPECTION ...

Aspects covered normally during RI of projects....

- Verification of Construction Completion Certificates, System Transfer Documents.
- Review of Engineering Change Notices and Field Change Notices.
- Emergency plans and effectiveness of emergency exercises for project personnel at the existing plant sites.



ENFORCEMENT ACTION

The enforcement action is based on

- **Safety significance of the deficiency**
- **Seriousness of violations**
- **Repetitive nature**
- **Deliberate nature of the violations**



ENFORCEMENT ACTION...

Several graded options are available for enforcement action:

- **A written directive for satisfactory rectification of deficiency or deviation noticed during RI**
- **A written directive for incorporating improvements within the reasonable time frame**
- **Order to curtail or stop activity**
- **Modification, suspensions or revocation of consent**



DECISIONS AFTER REVIEW AND ASSESSMENT

The Regulatory Body may issue or refuse a regulatory consent, taking into consideration the findings and recommendations of the Safety Review Committees and the Advisory Committee.

Bases for such decisions, interalia, are:

- **the extent to which the safety objectives and requirements have been fulfilled**
- **the acceptability of the depth and detail of the submission**
- **the state of knowledge with respect to particular processes or effects**
- **the confidence in the conclusions reached as a result of the analysis**



CONCLUDING REMARKS

Regulatory Consenting Process has been well formulated and has been standardized, especially for NPPs based on Pressurized Heavy Water Reactors, utilizing experience gained during licensing of such plants.

