

GUIDE NO. AERB/NPP&RR/SG/G-1



GOVERNMENT OF INDIA

GUIDE NO. AERB/NPP&RR/SG/G-1

AERB SAFETY GUIDE

**CONSENTING PROCESS FOR
NUCLEAR POWER PLANTS
AND RESEARCH REACTORS**



ATOMIC ENERGY REGULATORY BOARD

AERB SAFETY GUIDE NO. AERB/NPP&RR/SG/G-1

**CONSENTING PROCESS FOR
NUCLEAR POWER PLANTS
AND RESEARCH REACTORS**

**Atomic Energy Regulatory Board
Mumbai-400 094
India**

March 2007

Price

Orders for this guide should be addressed to:

The Administrative Officer
Atomic Energy Regulatory Board
Niyamak Bhavan
Anushaktinagar
Mumbai-400 094
India

FOREWORD

The Atomic Energy Regulatory Board (AERB) is entrusted with the responsibility for laying down safety standards and framing rules and regulations covering regulatory and safety functions envisaged under the Atomic Energy Act, 1962. AERB has therefore undertaken a programme of developing safety standards in the form of codes, guides and manuals for nuclear and radiation facilities, covering all aspects such as siting, design, construction, operation, quality assurance and decommissioning.

Safety codes establish the objectives and set minimum requirements that shall be fulfilled to provide adequate assurance for safety in nuclear and radiation facilities. Safety guides provide guidelines and indicate the methods for implementing the requirements as prescribed in the safety codes. Safety manuals are intended to elaborate specific aspects and may contain detailed technical information and/or procedures. Emphasis in these documents is on protection of site personnel, the public and the environment from unacceptable radiological hazards. The codes, guides and manuals are revised when necessary in the light of experience gained, feedback from users as well as new developments in the field.

AERB issued the safety code on 'Regulation of Nuclear and Radiation Facilities', to spell out the minimum safety related requirements/obligations to be met by a nuclear or radiation facility, to qualify for the issue of regulatory consent at every stage leading to eventual operation. This safety guide defines the regulatory consenting process at all the major stages of a nuclear power plant/research reactor. It covers in detail the information required to be included in the submissions to AERB, mode of document submissions and their classification, and areas of review and assessment for granting the regulatory consent.

Consistent with accepted practice, 'shall' and 'should' used in these documents distinguish between firm requirements and a desirable option, respectively. Appendices are an integral part of the document, where as annexures, bibliography and list of participants are included to provide further information on the subject that might be helpful to the user.

For aspects that are not covered in these documents, national and international codes and standards applicable and acceptable to AERB shall be followed. Industrial safety in nuclear and radiation facilities is to be ensured through compliance with the applicable provisions of the Factories Act, 1948 and the Atomic Energy (Factories) Rules, 1996.

The guide has been prepared by a Working Group consisting of AERB staff and other professionals experienced in this field. In its drafting, use has been made of information contained in the relevant documents of IAEA. Experts have reviewed the guide and the relevant AERB Advisory Committee has vetted it before issue.

AERB wishes to thank all individuals and organisations who have prepared and reviewed the draft and helped in its finalisation. The list of experts who have participated in the development of this document, along with their affiliations, is included for information.



(S.K. Sharma)
Chairman, AERB

DEFINITIONS

Anticipated Operational Occurrences

An operational process deviating from normal operation, which is expected to occur during the operating lifetime of a facility, but which, in view of appropriate design provisions, does not cause any significant damage to items important to safety nor lead to accident conditions.

Applicant

Any person who applies to the competent authority for consent to undertake any of the actions for which the consent is required.

Atomic Energy Regulatory Board (AERB)

A national authority designated by the Government of India having the legal authority and for issuing regulatory consent for various activities related to the nuclear radiation facility and to perform safety and regulatory functions, including enforcement for the protection of site personnel, the public and the environment against undue radiation hazards.

Authorisation

A type of regulatory consent issued by the regulatory body for all sources, practices and uses involving radioactive materials and radiation generating equipment.

Beyond Design Basis Events (BDBE)

Events of very low probability of occurrence, which can lead to severe accidents and are not considered as design basis events.

Commencement of Operation of Nuclear Power Plant

The specific activity/activities in the commissioning phase of a nuclear power plant, towards first approach to criticality, starting from fuel loading.

Commissioning

The process during which structures, systems and components of a nuclear or radiation facility, on being constructed, are made functional and verified in accordance with design specifications and found to have met the performance criteria.

Common Cause Failure (CCF)

The failure of a number of devices or components to perform their functions, as a result of a single specific event or cause.

Competent Authority

Any official or authority appointed, approved or recognised by the Government of India, for the purpose of the Rules promulgated under the Atomic Energy Act, 1962.

Consent

A written permission issued to the 'Consentee' by the regulatory body to perform specified activities related to nuclear and radiation facilities. The types of consents are 'licence', 'authorisation', 'registration' and 'approval', and will apply according to the category of the facility, the particular activity and radiation source involved.

Consentee

A person to whom consent is granted by the competent authority under the relevant Rules.

Construction

The process of manufacturing, testing and assembling the components of a nuclear or radiation facility, the erection of civil works and structures, the installation of components and equipment and the performance of associated tests.

Control System

A system performing actions needed for maintaining plant variables within prescribed limits.

Core Components

All items other than fuel, which reside in the core of a nuclear power plant and have a bearing on fuel integrity and/or utilisation (e.g. calandria, reactor vessel, coolant channels, in-core detectors and reactivity devices).

Core Damage

Reactor state brought about by the accident conditions, with loss of core geometry, or resulting in crossing of design basis limits or acceptance criteria limits for one or more parameters. (The parameters to be considered include: fuel clad strain, fuel clad temperature, primary and secondary systems pressure, fuel enthalpy, clad oxidation, % of fuel failure, H₂ generation from metal-water reaction, radiation dose, time required for operator to take emergency mitigatory action).

Criticality

The 'stage' or 'state' of a fissile material system where a self-sustained nuclear chain reaction is just maintained.

Decommissioning

The process by which a nuclear or radiation facility is finally taken out of operation in

a manner that provides adequate protection to the health and safety of the workers, the public and the environment.

Design

The process and the results of developing the concept, detailed plans, supporting calculations and specifications for a nuclear or radiation facility.

Design Basis Events (DBEs)

The set of events, that serve as part of the basis for the establishment of design requirements for systems, structures and components within a facility. Design basis events (DBEs) include operational transients and certain accident conditions under postulated initiating events (PIEs) considered in the design of the facility.

Diversity

The presence of two or more different components or systems to perform an identified function, where the different components or systems have different attributes, so as to reduce the possibility of common course failure.

Documentation

Recorded or pictorial information describing, defining, specifying, reporting or certifying activities, requirements, procedures or results.

Effluent

Any waste discharged into the environment from a facility, either in the form of liquid or gas.

Emergency Plan

A set of procedures to be implemented in the event of an accident.

Engineered Safety Features (ESF)

The system or features specifically engineered, installed and commissioned in a nuclear power plant, to mitigate the consequences of accident condition and help to restore normalcy, e.g. containment atmosphere clean-up system, containment depressurisation system, etc.

Exclusion Zone

An area extending up to a specified distance around the plant, where no public habitation is permitted. This zone is physically isolated from outside areas by plant fencing and is under the control of the plant management.

Exemption

The deliberate omission of a practice, or specified sources within a practice, from

regulatory control, or from some aspects of regulatory control, by the regulatory body, on the grounds that the exposures which the practice or sources cause or have the potential to cause, are sufficiently low as to be of no regulatory concern.

In-service Inspection (ISI)

Inspection of structures, systems and components carried out at stipulated intervals during the service life of the plant.

Level 1 PSA (Nuclear Reactor)

It evaluates core damage frequency by developing and quantifying accident sequences (event trees) with postulated initiating events together with system unavailability values derived from fault tree analyses with inputs from failure data on components, common causes and human actions.

Level 2 PSA (Nuclear Reactor)

It takes inputs from Level 1 PSA results and quantifies the magnitude and frequency of radioactive release to the environment following core damage progression and containment failure.

Level 3 PSA (Nuclear Reactor)

Taking inputs from Level 2 analysis, it evaluates frequency and magnitude of radiological consequences to the public, environment and the society considering meteorological conditions, topography, demographic data, radiological release and dispersion models.

License

A type of regulatory consent, granted by the regulatory body for all sources, practices and uses for nuclear facilities involving nuclear fuel cycle and also certain categories of radiation facilities. It also means authority given by the regulatory body to a person to operate the above said facilities.

Nuclear Material

Plutonium, except that with isotopic concentration exceeding 80% in plutonium-238, uranium-233, uranium enriched in the isotope 235, irradiated fuel (depleted or natural uranium, thorium or low enriched fuel of less than 10% fissile content), uranium containing the mixture of isotopes as occurring in nature other than in the form of ore or ore-residue, any material containing one or more of the foregoing.

Nuclear Safety

The achievement of proper operating conditions, prevention of accidents or mitigation of accident consequences, resulting in protection of site personnel, the public and the environment from undue radiation hazards.

Nuclear Security

All preventive measures taken to minimise the residual risk of unauthorised transfer of nuclear material and/or sabotage, which could lead to release of radioactivity and/or adverse impact on the safety of the plant, plant personnel, public and environment.

Operation

All activities following and prior to commissioning performed to achieve, in a safe manner, the purpose for which a nuclear/radiation facility is constructed, including maintenance.

Physical Protection

Measures for the protection of nuclear/radiation facility designed to prevent unauthorised access or removal of radioactive material, or sabotage.

Postulated Initiating Events (PIE)

Identified events during design that lead to anticipated operational occurrences or accident conditions, and their consequential failure effects.

Pre-Service Inspection (PSI)

The inspection performed prior to or during commissioning of the plant to provide data on initial conditions supplementing manufacturing and construction data as a basis for comparison with subsequent examinations during service.

Primary Containment

The principal structure of a reactor unit that acts as a pressure retaining barrier, after the fuel cladding and reactor coolant pressure boundary for controlling the release of radioactive material into the environment. It includes containment structure, its access openings, penetrations and other associated components used to affect isolation of the containment atmosphere.

Probabilistic Risk Assessment (PRA)/Probabilistic Safety Assessment (PSA)

A comprehensive structured approach to identifying failure scenarios constituting a conceptual and mathematical tool for deriving numerical estimates of risk. The terms PRA and PSA are interchangeably used.

Records

Documents, which furnish objective evidence of the quality of items and activities affecting quality. They also include logging of events and other measurements.

Radioactive Waste

Material, whatever its physical form, left over from practices or interventions for which no further use is foreseen : (a) that contains or is contaminated with radioactive

substances and has an activity or activity concentration higher than the level for clearance from regulatory requirements, and (b) exposure to which is not excluded from regulatory control.

Redundancy

Provision of alternative structures, systems and components of identical attributes, so that any one can perform the required function, regardless of the state of operation or failure of the other.

Regulatory Body

See “Atomic Energy Regulatory Board”.

Regulatory Clearance

A type of regulatory consent, which is issued for a nuclear facility during the intermediate stages of consenting process.

Regulatory Consent

A written permission issued to the ‘Consentee’ by the regulatory body to perform the specified activities related to nuclear and radiation facilities. The types of consent are ‘license’, ‘authorisation’, ‘registration’, and ‘approval’ and will apply according to the category of the nuclear/radiation facility, the particular activity and radiation source involved.

Reliability

The probability that a structure, system, component or facility will perform its intended (specified) function satisfactorily for a specified period under specified conditions.

Responsible Organisation

An organisation having overall responsibility for siting, design, construction, commissioning, operation and decommissioning of a facility.

Risk

A multi-attribute quantity expressing hazard, danger or chance of harmful or injurious consequences associated with an actual or potential event under consideration. It relates to quantities such as the probability that the specific event may occur and the magnitude and character of the consequences.

Risk Informed Approach

An approach to decision making that represents a philosophy whereby risk insights derived from risk assessment, by comparison of the results with the probabilistic safety goals, are considered together with other information obtained from deterministic safety analysis, engineering judgment and experience.

Safety Analysis Report

A document, provided by the applicant/consentee to the regulatory body, containing information concerning the nuclear or radiation facility, its design, accident analysis and provisions to minimise the risk to the public, the site personnel, and the environment.

Safety Assessment

A review of the aspects of design and operation of a source which are relevant to the protection of persons or the safety of the source, including the analysis of the provisions for safety and protection established in the design and operation of the source and the analysis of risks associated with normal conditions and accident situations.

Siting

The process of selecting a suitable site for a facility including appropriate assessment and definition of the related design bases.

Sterilised Zone

The annulus of specified radius around the plant, beyond the exclusion zone, where only natural growth is permitted and developmental activities which lead to growth of population are restricted by administrative control.

Surveillance

All planned activities, viz. monitoring, verifying, checking including in-service inspection, functional testing, calibration and performance testing, carried out to ensure compliance with specifications established in a facility.

Technical Specifications for Operation

A document approved by the regulatory body, covering the operational limits and conditions, surveillance and administrative control requirements for safe operation of the nuclear or radiation facility. It is also called the operational limits and conditions.

Ultimate Heat Sink

The atmosphere or a body of water or the ground water to which a part or all of the residual heat is transferred during normal operation, anticipated operational occurrences or accident conditions.

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1. INTRODUCTION

1.1 General

This guide supplements the safety code on Regulation of Nuclear and Radiation Facilities (AERB/SC/G), hereinafter referred to as the Code. This guide supersedes the AERB safety manual on Procedure Governing Authorisation of Nuclear Projects/ Plants, (AERB/SM/NSD-3).

The guide details the important stages for obtaining consent in respect of nuclear power plants (NPPs)/research reactors (RRs) and the nature of submissions to be made by the applicant at each stage. While specifying the requirements and making recommendations, the principle of grading of submissions and assessments based on importance to safety, of the concerned facility or its systems, has been kept in view.

The information contained in these submissions will enable assessment of the safety implications of the activity to which the consent relates and evaluation whether the overall risk that would be posed by the activity, will be acceptable to Atomic Energy Regulatory Board (AERB). The bases for the review and assessment will be the compliance with the safety objectives and specific requirements as specified in the relevant safety codes and guides, and those stipulated by AERB.

1.1.1 Safety Objectives and Requirements

Goals or levels of performance to be achieved by the plant should fulfil the safety objectives. Following safety objectives are generally specified for NPPs/RRs.

(a) General Nuclear Safety Objective:

To protect the plant personnel, the public and the environment from radiological hazards, by establishing and maintaining an effective defence against such hazards in NPPs/RRs.

(b) Radiation Protection Objective:

To ensure that during normal operation the radiation exposure within the plant and due to any release of radioactive material from the plant is kept as low as reasonably achievable and below prescribed limits and to ensure mitigation of the extent of radiation exposure due to accidents.

(c) Technical Safety Objective:

- To prevent with high confidence accidents in nuclear plants,

- To ensure that, for all accidents taken into account in the design of the plant radiological consequences, if any, would be minor, and
 - To ensure that the likelihood of severe accidents with serious radiological consequences is extremely small.
- (d) Nuclear Security Objective:
- To minimise the risk of unauthorised removal of radioactive material and nuclear material,
 - To minimise sabotage on nuclear power plants, and
 - To minimise the risk of adverse impact during the above acts.

1.2 Objective

The objective of this guide is to specify the relevant information to be submitted by the applicant at each stage, for being reviewed and assessed in order to evaluate the safety implications of the activity for which the consent is being sought. The guide is also meant to provide information on the methods of review and assessment, to be carried out by AERB, to determine whether:

- (a) the chosen site is suitable for the proposed type and capacity of the plant, from environmental considerations,
- (b) the proposed plant design and the applicant's statements and commitments meet the regulatory requirements,
- (c) the proposed construction will meet quality requirements,
- (d) the commissioning test program contains a well defined set of operational limits, conditions and procedures which are consistent with the regulatory requirements, could be safely conducted, and would verify the adequacy of all safety related features so as to ensure the performance of the plant as per design intent,
- (e) the operational limits and conditions (specified as technical specifications) are consistent with regulatory requirements and an adequate level of safety will be maintained during operation, through proper operational and maintenance procedures, and administrative control where required,
- (f) the organisational structures and training and qualification of the operating personnel meet the regulatory requirements,
- (g) the stated procedures for surveillance, operation, maintenance and emergency planning, are adequate,
- (h) the applicant's statements and commitments regarding decommissioning of the facility meet the regulatory requirements,

- (i) the results of commissioning tests confirm the adequacy of the design for regular operation of the plant at the rated capacity,
- (j) safety analysis for the as-built facility has been carried out to meet the regulatory requirements,
- (k) the operation of the plant could be carried out in accordance with the conditions of the consent granted,
- (l) after a stoppage mandated by AERB, the cause of stoppage has been satisfactorily resolved,
- (m) the conditions for renewal of consent as prescribed by AERB are met, and
- (n) the selection of the site and the design of the nuclear power plant meets the nuclear security objective as per the AERB requirements.

1.3 Scope

This guide defines the regulatory consenting processes at all the major stages of the NPP/RR. It covers in detail the information required, mode of document submission and their classification, and areas of review and assessment for granting the regulatory consents. The review and assessment procedures described in the document are generally applicable to all NPPs/RRs. The details with regard to requirements brought out in the document are specific to PHWRs. However, the information and requirements detailed in this document, may be found useful for other types of NPPs also.

2. REGULATORY CONSENTING PROCESS

2.1 General

2.1.1 The major stages of AERB's consenting process for NPPs/RRs are as follows:

- (a) Siting
- (b) Construction
- (c) Commissioning
- (d) Operation
- (e) Decommissioning

2.1.2 AERB may consider the safety review of design of NPP for its consentability even prior to siting. If the safety aspect of design of NPP is found acceptable, the deviation, if any, from the approved design may be reviewed in the respective consenting stages. This review should take into consideration site related aspects of the plant.

2.2 Regulatory Consenting Procedure

2.2.1 A consent is an official document issued in response to an application in a prescribed format [Form A given in Annexure-2] from the applicant, which:

- (a) allows a specified activity or set of activities dealing with the siting, construction, commissioning, operation or decommissioning of a nuclear power plant/research reactor;
- (b) prescribes requirements and conditions governing the performance of these activities;

2.2.2 The consent at the first major stage, namely siting, involves the review of the various site related safety aspects considering the conceptual design and issue of a consent for the site for locating the project. This requires, on the part of the applicant, submission of a site evaluation report (SER) which should include the site characteristics and basic design information of the proposed NPP/RR. The nature and contents of SER are indicated in Section 3.2.

2.2.3 The consent at the second major stage, namely construction, involves the review of the design safety aspects and issue of a construction consent. This requires, on the part of the applicant, submission of safety analysis report (preliminary) [SAR(P)], applicant's construction site quality assurance manual, construction schedule (major milestones including regulatory clearances) and construction methodology document for the proposed NPP/RR. As a supplement to SAR(P), separate design basis reports (DBR) and, if required, design reports (DR) of items important to safety, having relevance to

construction consent, should be progressively made available for review before consent for construction is issued. Depending on request from the applicant, AERB may issue the consent for construction as one time consent for total construction activities or as clearance in three stages, viz. clearance for excavation, clearance for first pour of concrete and clearance for erection of major equipment. If consent for construction is issued in these clearance stages, SAR (P) review will be organised according to the requirement for these clearance stages. The typical areas of review for these clearance stages are given in Appendix-9.

If a single consent for construction covering the entire construction stage is requested by the applicant, then the review of complete SAR (P) as given in Appendix-9 along with supporting/additional documents as necessary, should be organised by AERB before issue of the consent for construction. The applicant should provide clarifications to all the safety significant observations made/issues emanated during the course of review towards satisfactory resolution prior to issue of the consent for construction by AERB.

2.2.4 The consent at the third major stage namely Commissioning, is given in several interim stages. Typically for PHWR based NPPs, these interim stages/phases are:

Phase A:

- (i) hot conditioning or passivation of the primary system and light water commissioning;
- (ii) fuel loading* into the reactor core, and part borated heavy water addition to storage, cooling and moderator systems for flushing, in specified limited quantity, during which criticality is not possible;
- (iii) addition of heavy water to primary heat transport system; and
- (iv) bulk addition of heavy water to moderator system with minimum specified boron level in heavy water to prevent reactor criticality.

Phase B:

- (i) initial approach to criticality; and
- (ii) low power reactor physics tests and experiments.

Phase C:

- (i) initial system performance tests at low, medium and rated power levels, as determined by the stable operation of the turbine; and
- (ii) system performance at rated power.

* If fuel loading is to be taken up after bulk heavy water addition to moderator system, then regulatory consent shall be obtained prior to fuel loading.

AERB may consider modifications of the above mentioned interim stages, to add new stages/phases, or addition of new phases as considered necessary from safety considerations, in specific cases.

- 2.2.5 The consent for the fourth major stage called ‘Consent for Operation’ is for regular power operations at power levels up to rated power. The consent is granted after review of NPP’s performance at rated power within the commissioning consent. The period for power operation within the commissioning consent is normally of 100 days. For the consent for regular power operation, the applicant has to submit a safety analysis report (Final) reflecting the as built design cleared by AERB, detailed performance reports, status on and measures to resolve the pending issues if any, to support his application. The submissions required for this consent are given in Appendix-5. Subsequent to grant of this authorisation, the Advisory Committee on Project Safety Review (ACPSR) hands over the NPP to Safety Review Committee for Operating Plants (SARCOP) for ensuring safety during regular operation.
- 2.2.6 During regular operation, reviews are to be carried out to ensure that the operation of the plant is being carried out in accordance with the conditions of the consent granted. The safety supervision during operation mainly includes continual monitoring and assessment of operational and safety performances, regulatory inspection, renewal of authorisation and periodic safety review. For details, reference may be made to AERB safety guide on Regulatory Inspection and Enforcement in Nuclear and Radiation Facilities, AERB/SG/G-4 and AERB Code of Practice on safety in Nuclear Power Plant Operation, AERB/SC/O and all the safety guides made thereunder (AERB/SG/O-1 to O-16). As per Atomic Energy (Radiation Protection) Rules, 2004, the authorisation for operation can be issued for a maximum period of five years.
- Utility should submit Application for Renewal of Authorisation (ARA), in a prescribed format, which covers operational safety performance, operational experience feedback, physical status of plant and public concern in operational safety. The ARA report which is a self assessment study conducted by the utility should be submitted six months prior to the expiry of existing operating authorisation. AERB conducts a detailed review of the same and issues the authorisation after being satisfied that the plant could be operated in a safe manner for next five years. Comprehensive periodic safety review shall be carried out every ten years which also includes all the review provisions for renewal of authorisation in accordance with AERB/SG/O-12: ‘Renewal of Authorisation for Operation of Nuclear Power Plants’.
- 2.2.7 The consent for the final stage is for Decommissioning. Guides for this stage are being prepared. For review and assessment during decommissioning stage, reference may be made to AERB Safety Manual on Decommissioning (AERB/SM/DECOM-1).

2.2.8 While making submissions for issue of consent/clearance from the second stage, viz. construction onwards, the applicant should invariably include a status report on compliance with AERB's stipulations if any, made during the issue of the earlier consent/clearance.

2.3 Review and Assessment Process

2.3.1 General

Safety in siting, design, construction, commissioning and operation of the facilities is ensured primarily through regulatory actions including grant of consent for activities and imposition of conditions on the applicant. AERB performs these actions on the basis of its review and assessment. In general, a three-tier review process is followed by AERB before any major activity concerning NPP/RR, as defined in section 2.2, is granted consent. In certain cases AERB may opt for alternative review process as deemed necessary.

2.3.2 Review Process:

(a) The first level of review is by the first level safety committees viz the Site Evaluation Committee (SEC), Project Design Safety Committee (PDSC) or Civil Engineering Safety Committee (CESC), as appropriate. These committees are composed of experienced engineers and scientists, who as a body, comprise expertise in nearly all aspects of nuclear power project safety, and are constituted by AERB. These committees review the submissions, starting from site evaluation report (SER) up to the final test and commissioning reports. The committees may ask for clarifications, supplementary submissions and presentations. In addition, findings of any regulatory inspections and assessments by AERB are also considered by the committees. They also make visits to the sites to review the quality surveillance results and other site test results.

The safety committees may at their discretion, get some issues reviewed by specialist task force with members having the requisite background/expertise.

As a practical measure, review and assessment of each area may start at an earlier stage than, and then continue into stages subsequent to, the one in which it is a major area.

(b) The next level of review is conducted through an Advisory Committee on Project Safety Review (ACPSR). This Advisory Committee has as members experts drawn from other government organisations, academic research institutions and utility organisations. The ACPSR reviews the application for consent together with the recommendations of SEC/PDSC/CESC on the related consent and offers its own recommendations to AERB.

- (c) AERB as the designated consenting agency considers the recommendations of ACPSR, and decides on the consent.

2.3.3 Assessment Process:

- (a) For consideration of granting consent for a site for locating a project, the applicant is required to furnish the site evaluation report (SER) highlighting site related aspects to AERB. This document is referred to the site evaluation committee (SEC). In case special investigations and verifications are called for, the SEC with the approval of AERB may entrust the same to specialist agencies/consultants.

The findings and recommendations of the SEC, are passed on to the Advisory Committee for Project Safety Review (ACPSR). This committee reviews the findings of the SEC, and makes recommendations to AERB. Any issue remaining unresolved by the SEC, will also be referred to ACPSR.

The findings and recommendations of ACPSR are considered by AERB for grant of consent for locating the project at the Site.

The schematic of this three-tier review is shown in Figure 2.1.

- (b) Three-tier regulatory review is followed for grant of consent for construction. As mentioned in Section 2.2.3, construction consent may be given either in three sub-stages, namely excavation (Sub-stage-I of construction consent), first pour of concrete (Sub-stage-II of construction consent) and erection of major equipment (Sub-stage-III of construction consent), or for entire construction, based on the request from the applicant. The documents to be submitted/ required for review depends on whether the applicant is seeking complete construction authorisation or in sub-stages; this aspect is covered in Section 3.22 and Appendix-9. The assessment requirements are covered in Section 5.3.

The first tier review is conducted by both Project Design Safety Committee (PDSC) and Civil Engineering Safety Committee (CESC). The applicant submits his document to either PDSC or CESC depending on the subject for completing the first tier review. The second tier review is done by ACPSR. ACPSR may meet more often, if required, depending upon issues. The third tier review for consent is conducted by the Regulatory Board. The schematic of this review is presented in Fig 2.2.

- (c) For grant of consent for commissioning, the applicant is required to submit the relevant documents as identified in Section 3, in support of the application. The first tier review is conducted by the Project

Design Safety Committee (PDSC). The second tier review is by the ACPSR, and the third tier review for consent is conducted by the Regulatory Board. The typical schematic of this review is presented in Fig. 2.3.

- (d) A similar review scheme is followed for operation stage. The typical schematic for consent of operation stage is given in Fig. 2.4.
- (e) In addition to the above reviews, committees specially constituted from time to time, will carry out the reviewing tasks assigned to them by AERB, in respect of safety issues arising during commissioning and operation.

2.4 Channels of Communication

- 2.4.1 It is essential that, proper channels of communication between the different parties involved, be clearly established, at the earliest possible stage of the consenting process. This should facilitate a smooth and continuous flow of information and documents to AERB for its review and assessment, and expedite the consenting process.

To facilitate communication the following should be in place.

- (a) The applicant should designate a group or an individual, who will be the coordinating agency with AERB for a specific project. This coordinating agency will interact with the concerned committee for routine communication.
- (b) The applicant should submit the documents to the group designated by AERB for the purpose. Any reference to one committee by other committee is organised by the member secretary of the requesting committee.

2.5 Appeal Against Decisions

- 2.5.1 An appeal against the decision(s) of the Board of the regulatory body shall lie with the Atomic Energy Commission whose decision will be final.
- 2.5.2 An appeal against the orders of the regulatory body will be reviewed by the Board of the regulatory body for appropriate further action. However, it shall be obligatory for the concerned institution to implement the directives of the regulatory body not with standing any appeal being filed by the institution.

3. INFORMATION NEEDED FOR ISSUE OF CONSENTS

3.1 General

The requirements in respect of availability/submission of various documents and the stage of clearance at which they are required are identified in section 3.22. Any other document found necessary during the course of review by AERB should be submitted in timely manner. The following sections, 3.2 to 3.20, give guidance on the contents of some of these documents. In addition to the documents described below, the applicant should also arrange presentations for AERB before beginning the formal review. The depth and schedule of a presentation should depend on whether the project is of new, evolved or repeat design. The information submitted should include operational experience feedback.

3.2 Site Evaluation Report

Information relating to the site, with particular emphasis on factors important to radiation safety, emphasising those site characteristics which may influence the engineering and operation of the plant, shall be provided. Information regarding the interaction of the facility and the environment shall also be provided. Information regarding the electrical grid of the region and power evacuation scheme, where applicable, should be furnished. The report should also contain basic design information of the proposed plant. The report should also evaluate the given information for justifying the suitability of the site for the proposed plant.

Guidelines on the contents of site evaluation report (SER) are given in Appendix-1.

3.3 Safety Analysis Reports (Preliminary/Final)

In the regulation of reactors, safety reports form the principal communication between the applicant and AERB. Therefore, the main purpose of safety report is to:

- (a) provide an evaluation by the applicant of the proposed facility and demonstration that the facility can be built and operated at the proposed site, without undue risk to the health and safety of the general public. The evaluation should take into account feedback from experience with similar facilities/components and experimental results.
- (b) provide information, such as design bases, site and plant characteristics, safety analyses and conduct of operations, in such a way that AERB may evaluate the safety of the plant.

The achievement of a high level of safety should be demonstrated primarily in a deterministic way. However, the safety analysis should incorporate both deterministic and probabilistic approaches. Annexure-3 and 4 give typical formats for reporting of deterministic (accident) and probabilistic safety analysis respectively.

Refer Appendix-2 for the contents of safety analysis report for PHWR and Appendix-3 for the contents of safety analysis report for research reactor.

3.4 Design Basis Report (DBR)

The design basis report (DBR) of systems should contain the following aspects of the design.

- (a) System Description : This should include general description of the system, its function and interfaces. It should include flow diagrams, and instrumentation diagrams as applicable. It should be further supplemented by figures, and sketches to bring out the function and interfaces of the systems.
- (b) System Operation : This should bring out system operations during normal and off-normal conditions as conceived by the designer.
- (c) Design Approach : This should bring out the assumptions, basic input data, design basis, applicable codes/guides, safety features as applicable, surveillance requirements, and radiological aspects.
- (d) Safety Evaluation : These should bring out postulated initiating events against which the system will be designed to perform as intended.

3.5 Report on Design Basis Ground Motion

The report should cover geological and seismological investigations including site seismicity based on historical earthquake data, recorded earthquakes, site specific instrumentation, and other geological investigations on faults and ground failure aspects. Derivation of design basis ground motion should cover in detail seismotectonics and lineaments map of the site, design basis earthquake levels, peak ground accelerations, response spectra and time histories in two orthogonal horizontal and vertical directions. The report should contain all information as required by AERB safety guide titled 'Seismic Studies and Design Basis Ground Motion for Nuclear Power Plant Sites', AERB/SG/S-11.

3.6 Report on Geotechnical Investigations and Foundation Parameters

The report should cover topology and geology of the site, sub surface condition and profiles, boreholes, trial pits, water table, various field tests for determination of foundation parameters including geophysical tests,

permeability tests and load tests, soil/rock sampling and laboratory tests related to geotechnical characterisation and strength parameters. The report should also cover evaluation of suitability of the soil/rock as foundation medium and evaluation of foundation design parameters.

Confirmatory geotechnical and geological investigations are required to be carried out after foundation excavation. The report on confirmatory investigation should include geological mapping of the excavated foundation pits of RB, results of confirmatory geotechnical and geological investigations, and confirmation of the foundation parameters adopted in the design using the results of the confirmatory investigation.

3.7 Report on Design Parameters for Meteorological Events

This report should cover data collection, data analysis and evaluation of design parameters for structural design with regard to wind, rainfall, flooding, temperature, humidity and any other site-specific meteorological event.

3.8 Report on Site Grading and Surface Drainage

This report should cover derivation of finished grade levels of the main plant complex and design of plant drainage to avoid flooding of the site and various safety related plant buildings.

3.9 Reports on Civil Engineering Structures Important to Safety

Design Basis Reports (DBR):

- (a) General description:
Functional and physical description of the structure, safety requirements, safety and seismic classification, layout.
- (b) Applicable design codes, standards and specifications.
- (c) Materials of construction, material properties.
- (d) Loads and load combinations.
- (e) Design and Analysis Procedures:
Analysis methodology, mathematical model, design for strength and serviceability, important assumptions in analysis and design, seismic analysis methodology, soil structure interaction, structure-structure interaction, hydrodynamic aspects, design requirements pertaining to geotechnical safety and foundation design, structural acceptance criteria.
- (f) Construction and maintenance aspects, provisions for in-service inspection.
- (g) Special requirements, if any, such as tests, structural instrumentation, fire protection, decommissioning, special construction techniques.

Dynamic Analysis Reports (DAR):

These reports should cover in detail all aspects of dynamic analysis including modelling aspects, input parameters, dynamic characteristics of the structure, generation of floor response spectra and important results (i.e. output).

Design Reports (DR):

These reports should present input parameters for analysis and design, calculation of design forces from analysis results, sample design calculations and specific design features, if any.

Design Basis Report on Shielding (DBRS):

DBR on shielding should cover in detail the bulk shielding aspects of concrete structures used as shielding for radioactive systems, components and structures. It should also cover layout and shielding of penetrations through these shielding structures. Layout of areas/rooms containing active systems/equipment requiring shielding should also be covered in detail with respect to structures (walls and slabs) used for shielding.

3.10 Documents on Industrial Safety during Construction

(a) Job Hazard Analysis Report:

This report should include the following

- Main activities/tasks.
- Sub-activities.
- Hazards associated with sub-activity/task including cause and consequence analysis.
- actions and action plans to prevent/control/mitigate the hazards

(b) Construction Safety Management Manual:

This manual should include in detail the following.

- Safety policy, organisation chart and responsibilities for departmental as well as contractor (principal contractor should be held responsible for sub-contractors) personnel.
- Safety manpower qualifications, experience, training and competency to perform assigned duties.
- Job safety procedures to prevent/control hazards due to various agencies in the construction environment.
- Job control/work permit system.

- Job inspection/supervision and enforcement methodology, agencies and accountability.
 - Accident reporting and investigation system.
- (c) Supporting documents for Industrial Safety during Construction:
- These include following:
- (i) Procedures for controlling the movement of earth moving machinery, concrete mixing and pouring system, lifting machinery.
 - (ii) Procedures for carrying out inspection of excavation activities.
 - (iii) Procedures for carrying out inspection of concrete handling, mixing, pouring, form work/shoring activities, stair cases, ladders and ramps.
 - (iv) Procedures for carrying out inspection of rigging operations, platforms, staircases, ladders and ramps, working at heights, welding and cutting and supporting.
 - (v) Control measures to prevent cave-in, land sliding, water accumulation, run-off due to rain, loose excavated material falling/rolling, etc.
 - (vi) Control measures to prevent failure of formwork/shoring, fall of personnel/materials from height.
 - (vii) Safety training procedure/manual for departmental/contractor personnel.
 - (viii) Test certificates for all lifting machinery, lifting tools and tackles.
 - (ix) Safety work permit procedures for blasting, excavation, concrete handling activities, all erection activities especially involving heights etc.
 - (x) List of competent persons under various sections of the Factories Act, 1948.
 - (xi) Certification of concrete handling, mixing, pouring and form work/shoring by a competent civil/structural engineer.
 - (xii) Certification of platforms, scaffoldings, rigging methods, hand tools and powered tools by a competent engineer.
 - (xiii) Fire order.

3.11 Construction Methodology Document and Report on Concrete Mix Design:

The construction methodology document should cover specific construction/erection aspects of various structures vis-à-vis design intent and quality

requirements, general descriptions of various structures, materials of construction, sequence of construction, pour size and sequence, construction joints, form work and shuttering, handling of concrete (viz. production, delivery, placement, compaction, curing), control of concrete temperature, adequacy of construction machinery and manpower, etc.

The report on concrete mix design should cover qualification of concrete ingredients, trial mix details, laboratory tests, field trials including all tests necessary for qualification, acceptance of the mix design and its suitability under field conditions.

The construction methodology document should also cover specific design intent and quality requirement with respect to shielding design of the structure (concrete). The report on concrete mix design should cover qualification of concrete gradients and all tests necessary for the qualification and acceptance of concrete structures used for shielding purpose.

The construction methodology should also address the qualification, testing and acceptance of embedded parts within the concrete structures designed for shielding purpose.

3.12 Organisation for Commissioning and Operation

Information on the applicant's organisational set up for the commissioning and operation stages shall be provided. In particular it should include the following:

- (a) A description of the applicant's organisational structure including the fields of responsibility and competence. The applicant should demonstrate that he will have a staff of adequate size, training and technical competence for commissioning and operating the nuclear power plant.
- (b) Assurance about the quality of the vendors engaged and compliance with the provisions of other relevant safety, health and environmental statutes.
- (c) A description of the applicant's organisation for radiological protection and industrial safety and of the provisions for appropriate medical services.
- (d) A description of the organisation for inspection, maintenance and testing and for ensuring that design specifications are complied with.
- (e) A description of the organisation for life management.
- (f) A description of the applicant's organisational arrangements for safety review of commissioning and operation, including description of committees.

3.13 QA Manual

The QA manual is required to ensure that relevant activities are carried out in a planned and systematic manner and that the quality of work is according to the requirements of approved documents and nuclear industry practice. The QA manual for design, construction, commissioning and operation should be prepared separately.

The QA manual should include policy statement of top management's commitment to achievement of quality in organisational set up, responsibilities of organisational groups, etc., as part of management functions. For performing such functions information on the following should be brought out.

- planning at each phase,
- document control,
- procurement control,
- receipt/storage/handling of material/equipment,
- training of personnel,
- qualification of processes,
- non conformance control, and
- corrective action.

The manual should also include information on quality assurance plans, internal audit, non-conformance control and verification, etc., and finally QA records and their retrieval.

There are certain QA requirements specific to each phase of the project such as:

for design

- development of design,
- design activities,
- preparation of DBRs,
- technical specifications,
- drawings,
- design manuals,
- software control, etc.

for construction

- construction planning,

- design document control,
- construction control, etc.

for commissioning

- procedures and instructions,
- phases of commissioning,
- house keeping and cleanliness control,
- verification of design intent
- generation of base line data, etc.

and for operation

- security and access control,
- performance functions (e.g. work control, preparation and approval of procedures and support documents, equipment control, surveillance, testing and ISI),
- housekeeping ,
- emergency control,
- measuring and test equipment,
- operating procedures, etc.

The above aspects should be brought out in detail in the respective QA manuals based on requirements specified in AERB codes and guides on QA (Appendix-8).

3.14 Technical Specification for Operation

3.14.1 The applicant shall submit technical specification for operation, containing proposed operational limits and conditions for the safe operation of the NPP/RR.

The operational limits and conditions should emphasise two broad categories of technical factors, namely:

- (a) Those relating to the prevention of situations that could involve significant hazard from ionising radiation, and
- (b) Those relating to the mitigation of the consequences of such situations should they arise.

In accordance with the above, limits and conditions should be established to cover the following:

- (i) Safety limits

- (ii) Safety system settings
- (iii) Limiting conditions for operation
- (iv) Surveillance requirements including maintenance, in-service inspection and periodic testing.

Since safety during operation depends on personnel as well as equipment, the proposed operational limits and conditions should also cover organisational and administrative aspects of operation having a bearing on safety.

The administrative and technical procedures and methods employed to deal with situations when operational limits and conditions are exceeded, should be described and justified.

Details of information needed are identified in safety guide AERB/SG/O-3, 'Operational Limits and Conditions for Nuclear Power Plants'.

3.15 Operation Information and Document

3.15.1 Plant's Safety Policy

Plant should have a safety policy document which should include methodology and arrangement to fulfil organisation's commitment to safety and safety culture.

3.15.2 Organisational structure and division of responsibility shall indicate the following:

- (a) A functional description of the structure of the plant management.
- (b) Qualifications established as prerequisites for key positions within the organisation.
- (c) The lines of responsibility and authority for both operation and safety.
- (d) The approximate number of personnel to be assigned to the organisation as a whole, and to individual health and safety branches.

3.15.3 Emergency plans (on-site and off-site) should identify the following as appropriate:

Organisation for coping with radiation emergencies, assessment action, activation of emergency organisation, notification procedures, emergency facilities, training, emergency preparedness and recovery (refer AERB/SG/O-6, EP-1, EP-2).

3.15.4 Operating Procedures

The applicant shall certify that the required operating programs and the operating procedures are prepared. This should cover the following:

- (a) Start-up
- (b) Normal operation
- (c) Shutdown
- (d) Refuelling, fuel handling and transport
- (e) Work permit procedure
- (f) Maintenance
- (g) Periodic testing
- (h) In-service inspection
- (i) Anticipated operational occurrences and emergency conditions
- (j) Emergency operating procedures - EOPs
- (k) Reporting and analysis of unusual operational occurrences and corrective action.

3.15.5 Records

The applicant shall certify that arrangement for the following is in place:

Identification of principal records to be maintained, e.g.

- (a) daily logs of operations,
- (b) record of tests,
- (c) records of inspections and measurements,
- (d) records of radioactivity released to the environment,
- (e) records of monitored safety limits,
- (f) records of changes made in the plant and the operating procedures,
- (g) records of QA and safety audits,
- (h) occupational dose records,
- (i) records of health examination.

3.15.6 Operational reports shall be submitted to AERB periodically for normal operation and according to agreed schedules for anticipated operational occurrences and emergency response exercises/drills.

Anticipated operational occurrences and accident conditions should be reported immediately within a specified time interval or in the periodic reports, depending on their safety significance.

3.16 Training and Qualification Program

Training program should consist of the following:

- (a) Training and licensing of the operating staff for initial start-up and routine operation including the use of simulators, as applicable, for simulation of normal as well as postulated accident conditions.
- (b) Training of replacement personnel for plant operation.
- (c) On-the-job training and skill up-dating of operating personnel.

The program should include the time schedule for training and qualification of operation and maintenance personnel such that the required number of qualified and licensed personnel are available at the appropriate commissioning stages.

3.17 Commissioning Related Submissions

The submissions/requirements during various stages of commissioning covering system status/commissioning test results should be as per Appendix-4 which is typical for PHWRs. These submissions should be submitted with designer's review and acceptance.

3.18 In-service Inspection and Testing Program

The in-service inspection and testing program should cover the entire service life of the plant, to monitor the quality status of various components. The information on ISI should bring out the bases, categorisation of areas subject to inspection, inspection techniques, frequency of inspection, acceptance criteria, etc. (AERB safety guide No. AERB/SG/O-2 on 'In-service Inspection of Nuclear Power Plants' should be referred).

3.19 Radiation Protection Procedure

It should include information on

- Organisational Structure bringing out the role of station health physicist
- Maximum permissible exposures
- Radiological measurements and their assessments
- Work techniques and protective equipment
- Incident and emergencies
- Shipment of radioactive material, etc.

3.20 Fire Hazard Analysis

To determine the fire resistance of the fire area boundaries and the requirement of the fire extinguishing systems and fire barriers, a fire hazard analysis is necessary. Fire hazard analysis should be performed or updated early in the design stage, prior to initial commissioning and whenever significant change is made as outlined in the AERB documents.

- (a) Standard for fire protection systems of nuclear facilities (AERB/S/IRSD-1)
- (b) Safety guide on Fire protection in Pressurised Heavy Water Reactor Based Nuclear Power Plants (AERB/SG/D-4)

3.21 Physical Protection

The applicant should submit, on a confidential basis, details of physical protection system design covering design basis threats to show that:

- Suitable technical and administrative precaution will be taken in order to prevent persons from carrying out unauthorised actions, which could jeopardise safety whether willfully or otherwise.
- Arrangements are made where by only persons, vehicles and materials authorised in accordance with the written procedures are on the site.
- Effective provision to detect and assess any violations of these security arrangements are in place.
- Provision of physical protection system in nuclear power plant design ensures sufficient delays for intrusion.
- Provision of security-measures ensures plant is operated in the configured mode.
- Provision has been made for proper liaison with competent authority for timely assistance to neutralise the threat.
- Methodology for training/certification/licensing of plant and security personnel is in place.
- Documentation and reporting aspects have been spelt out.
- Aspects of quality assurance have been covered.

For details on physical protection and nuclear security aspects, AERB manual on Nuclear Security of Nuclear Power Plant should be referred.

3.22 Lead Time for Submission/Availability of Documents

The lead time given below is indicative for the purpose of planning submissions of documents and provides for minimum time required for safety review of documents by AERB. In specific cases such as plant based on new design AERB may specify longer lead time. The consentee should submit the application for the stage for which consent is requested in the format specified (Annexure-2) along with the relevant submissions as are required in the application and also as per the table given below.

S.No.	Document	Advance availability	Para in text
SITING			
1	Site Evaluation Report	Nine months prior to expected date of Siting Consent.	3.2
CONSTRUCTION			
1(a)	Safety analysis report (preliminary) - Containing all chapters and other relevant documents as per Section 4.3 & 4.4. For obtaining single consent for construction - repeat design	12 Months prior to expected date of start of construction activity at the approved site After submission of documents, a preliminary review will be taken up to assess the adequacy of coverage of design and safety requirements given therein and the applicant will be informed accordingly. This review could take about 3 months depending upon the inputs received. The review for construction consent will be taken up after submission of the modified/improved safety analysis report (preliminary) [SAR(P)] document considering the outcome of preliminary review. The complete review of modified SAR(P) could take about 9 months thereafter.	3.3
1(b)	Safety analysis report (preliminary)- Containing all chapters and other relevant documents as per Section 4.3 & 4.4. For obtaining single consent for construction - new design	30 months prior to expected date of start of construction activity at the approved Site After submission of documents, a preliminary review will be taken up to assess the adequacy of coverage of design and safety requirements covered therein and the applicant will be informed accordingly. This review could take about six months depending upon the inputs received. The review for construction consent will be taken up after submission of the modified/improved SAR(P) document considering the outcome of preliminary review. The complete review of modified SAR(P) could take about 24 months thereafter.	3.3
1(c)	Safety analysis report (preliminary)	Consent for site excavation-6	3.3

S.No.	Document	Advance availability	Para in text
1(c) (Contd.)	- In parts containing relevant chapters as required for the three sub-stages of construction consent for near and repeat designs.- As per Appendix-9.	<p>months prior to the commencement of the activity.</p> <p>After submission of documents, a preliminary review will be taken up to assess the adequacy of coverage of design and safety requirements given therein and the applicant will be informed accordingly. This review could take about 2 months depending upon the inputs received.</p> <p>The review for site excavation consent will be taken up after submission of the modified/improved chapters of SAR(P) document considering the outcome of preliminary review. The complete review of modified chapters of SAR(P) could take about 4 months thereafter.</p> <p>Consent for first pour of concrete(FPC)-15 months prior to the commencement of the activity.</p> <p>After submission of documents, a preliminary review will be taken up to assess the adequacy of coverage of design and safety requirements given therein and the applicant will be informed accordingly. This review could take about 3 months depending upon the inputs received.</p> <p>The review for consent for FPC will be taken up after submission of the modified/improved chapters of SAR(P) document considering the outcome of preliminary review. The complete review of modified SAR(P) could take about 12 months thereafter.</p> <p>Consent for equipment erection (EE) -15 months prior to the commencement of the activity.</p> <p>After submission of documents, a preliminary review will be taken up to assess the adequacy of coverage</p>	

S.No.	Document	Advance availability	Para in text
1(c) (Contd.)		of design and safety requirements given therein and the applicant will be informed accordingly. This review could take about 3 months depending upon the inputs received. The review for consent for EE will be taken up after submission of the modified/improved chapters of SAR(P) document considering the outcome of preliminary review. The complete review of modified SAR(P) could take about 12 months thereafter.	
2(a)	Report on design basis ground motion, geotechnical investigations and foundation parameters. Design parameters and requirements for bulk shielding, penetrations through bulk shielding and lay out of areas/rooms containing radioactive systems/components/equipment.	One year prior to expected date of excavation consent	3.5, 3.6, 3.7, 3.8
(b)	Design parameters for meteorological events.	6 months prior to site excavation	
3	Job hazard analysis report (in three phases)	Two months prior to start of site construction (excavation, first pour of concrete and erection of major equipment)	3.10(a)
4	Construction safety management manual	Four months prior to start of site construction (site excavation)	3.10(b)
5	Supporting documents for industrial safety	One month prior to construction (excavation, first pour of concrete and erection of major equipment)	3.10(c)
6	QA manual for - design - construction	Three months prior to start of design safety review Six months prior to start of FPC	3.13
7	Construction schedule (from ground breaking to scheduled criticality), Excavation drawings (general arrangement showing all safety aspects, slopes and approaches), report on site grading and surface drainage, confirmatory geotechnical investigation report, report on concrete mix design and construction methodology document.	Three months prior to start of site excavation	2.2.3, 3.5, 3.6, 3.8, 3.11

S.No.	Document	Advance availability	Para in text
8	Design basis reports and design reports for items important to safety	Available as supporting documents 3 to 9 months prior to scheduled date of review as agreed by RB.	3.4
9	Reports on civil engineering structures important to safety and their adequacy for shielding (whenever used for shielding of radiation sources, systems/ components/ equipment.	12 months (DR, DAR, DBR) prior to commencement of construction of the respective structure.	3.9
10	Details of construction colony(for existing sites)	Three months prior to start of site excavation	
11	Emergency preparedness plan covering the project construction personnel(for existing sites)	Three months prior to start of site excavation	
12	Nuclear security aspects relevant to construction phase	Report to be submitted 6 months prior to expected date of site excavation.	
COMMISSIONING			
1	QA manual for - commissioning - operation	Three months prior to start of commissioning Three months prior to criticality	3.13
2	Schedule for commissioning program	Two months prior to start of hot conditioning	
3	Organisation for commissioning and operation	Three months prior to start of hot conditioning	3.15.2
4	Technical specifications for operation	Three months prior to fuel loading/ heavy water addition, whichever is later, for standard design reactors; Six months for new type of reactors	3.14
5	Training and qualification program (including schedule for licensing key operating personnel)	Three months prior to fuel loading / heavy water addition, whichever is later	3.16
6	Approved emergency preparedness plans for plant, site and off-site	Available prior to first approach to criticality	3.15.3
7	Complete set of flow sheets and logic diagrams	Available at site prior to commissioning	
8	Commissioning related submissions covering system status and test results (Typical list for a PHWR in Appendix-4)	Six weeks for major consent (hot conditioning/criticality), other interim stages one week before commissioning	3.17
9	Waste management operation manual	Available prior to first approach to criticality	

S.No.	Document	Advance availability	Para in text
10	Radiation protection procedure	Available three months prior to first approach to criticality	3.19
11	Fire order with available provisions	Available three months prior to first approach to criticality	
12	In-service inspection manual	Available two months prior to first approach to criticality	3.18
13	Operating manuals	Available at site prior to fuel loading	3.15.4
14	Maintenance procedures.	Available at site prior to start of initial power operation	3.15.4
15.	Emergency operating procedure (EOPs)	Available prior to first approach to criticality	3.15.4
16.	Level-1 PSA studies for internal and external events	Available 3 months prior to first approach to criticality	3.3
17.	Manual on nuclear security measures.	To be submitted 3 months prior to start of commissioning (hot conditioning of PHT for PHWRs/ hot run for PWRs)	3.21
18.	Fire hazard analysis (FHA)	Three months prior to start of commissioning	3.20
OPERATION			
1.	Safety analysis report (Final) [SAR(F)]	Two months prior to request for consent for operation	3.3
2.	Other submissions as specified in Appendix-5	Two months prior to request for consent for operation	

4. CLASSIFICATION AND FORMAT OF DOCUMENTS

4.1 Introduction

Section 3 dealt with the nature of the information that should be submitted by the applicant to AERB in support of the application for consent. The documents containing such information may be classified under the following headings.

- (a) Main documents
- (b) Supporting documents
- (c) Reference documents

This classification is explained in sub-sections 4.2 to 4.4. With regard to the format of documents, general guidelines are suggested in sub-section 4.5.

4.2 Main Documents

Main documents to be submitted are those containing information essential to review the nuclear power plant's safety. They should be submitted with the application for the desired consent. Main documents shall include:

- (a) Site evaluation report (see sub-section 3.2)
- (b) Safety analysis reports (see sub-section 3.3)
- (c) Organisation for commissioning and operation (see sub-section 3.12)
- (d) Quality assurance manual (see sub-section 3.13)
- (e) Operation information and document (see sub-section 3.15)
- (f) Commissioning related submissions (see sub-section 3.17)
- (g) Physical protection (see sub-section 3.21)
- (h) Fire hazard analysis (see sub-section 3.20)

As indicated in section 3.22, it should not be considered necessary, at the early stages of the development of the project, to provide detailed information on all of the above mentioned subjects. It may be necessary to revise and update the documents during the construction and commissioning stages, so that together with supporting documents, all information needed to support a request for an operating consent is presented. Main documents should be subject to revisions which reflect the most recent state of the plant/facility.

4.3 Supporting Documents

Supporting documents are defined here as those which contain information that complements the information provided by the main documents. They

need not necessarily be submitted at the time of the request for the desired consent. They should, however, be provided, if required and reviewed before the issue of a consent. Supporting documents usually include:

- (a) Design basis reports (DBRs) and flow sheets for assisting review
- (b) In-service inspection programs and reports
- (c) Detailed stress analyses reports.

It should be understood that AERB may demand the submission of any other supporting document which may be needed during the consenting process.

4.4 Reference Documents

Reference documents are defined here as those which are not usually supplied as part of the required documentation during the consenting process but which should be made available on demand and reviewed if found necessary for consenting process. The following are only examples of documents which may fall in this category:

- (a) Detailed design analysis
- (b) Relevant calculations, e.g. those pertaining to accident analysis, component integrity and radiological impact.
- (c) Q A procedures
- (d) Commissioning reports
- (e) Reports on associated safety research, development and testing programs
- (f) Training documents and operating flow sheet
- (g) General maintenance procedures
- (h) Environmental studies reports
- (i) Operating manuals
- (j) Completion assurance for construction and commissioning (construction completion certificate and system transfer documents)

4.5 Format of Documents

The following guidelines relating to the format of the documents should be followed.

- (a) A table of contents should be provided. When a document consists of several volumes, the summary table of contents should be included in each volume.
- (b) Each section of the document should cover a particular system or topic and be self-contained to the extent possible.

- (c) All information presented in drawings, maps, diagrams, sketches and charts should be legible, the symbols should be defined, and the drawings should be to a scale which does not necessitate the use of visual aids.
- (d) Abbreviations should be consistent with general usage. Those not in general usage should be defined in each volume where they are used.
- (e) Outdated text and data should be removed and replaced by inserting revised pages issued with updated text and data. In the safety analysis report, removal and insertion of pages should be made easy. Changes should be highlighted by a vertical line in the margin or some other effective indication. All pages submitted to update, revise or add information to the document should show the date of issue and a change or amendment number.
- (f) The information presented in the main body of the document should be supplemented, as necessary by appendices. All documents and drawings should be checked and approved by person authorised.

5. STAGES OF REVIEW AND ASSESSMENT

5.1 General

Consenting should be considered as an ongoing process, which starts at the siting stage and continues through the decommissioning of the plant/facility. This section describes the areas in which review and assessment efforts should be concentrated to determine, before consenting decisions are taken, whether the safety objectives have been met. In this section the areas are grouped according to the main consenting stages as detailed in the Code.

5.2 Regulatory Consent for Siting

The site should be reviewed and assessed to determine the potential consequences of interaction between the plant and the site and the suitability of the site for the proposed plant from the point of view of safety. The consent should be issued for a limited period, say 3 years. If no site activity starts within 3 years, the consent for the siting should be subject to review by AERB for issue of fresh consent.

Appendix-6 gives the typical levels of safety review for siting stage.

Review and assessment areas of particular significance include:

- (a) Those related to environmental conditions and aspects which will influence the design basis of the plant/facility, namely:
 - (i) Geology and soil mechanics
 - (ii) Topography
 - (iii) Hydrology and hydro-geology
 - (iv) Meteorology
 - (v) Natural phenomena such as earthquakes, floods and tornadoes
 - (vi) Potential external man-induced events such as plane crashes, fires and explosions
 - (vi) Failure of man-made structures such as dams and sea walls
 - (viii) Availability of water for plant cooling and requirement of ultimate heat sink
 - (ix) Reliability of off-site electrical power
- (b) Those related to the effects of the plant on the environment that could warrant specific design or operational requirements, namely:
 - (i) Dispersion of radioactive liquid effluents

- (ii) Dispersion of radioactive gaseous effluents
- (iii) Radiation exposure of the public arising from liquid and gaseous radioactive effluents released during normal operation, anticipated operational occurrences and accident conditions, taking into account dispersion patterns, present and prospective population distribution, public water supply, milk and food consumption, and radioecology.
- (c) Availability of roads and access features for emergency response purposes.
- (d) Aspects on nuclear security measures with reference to site characteristics.

5.3 Regulatory Consent for Construction

5.3.1 The design of the plant should be reviewed and assessed to reach a conclusion as to whether it can be built to operate safely. This review and assessment should include verification of the compatibility of the design with the site. The quality assurance organisation and program should be reviewed.

5.3.2 Review and assessment areas of particular significance are as detailed below:

5.3.2.1 General Design Considerations

- (a) Safety approach of the applicant (objectives and principles) especially the importance given to such topics as accident prevention, surveillance and means of intervention and mitigation, defence in depth, redundancy, physical separation and diversity.
- (b) Safety classification of systems, structures and components
- (c) Design basis, ground motion, geo-technical investigations and foundation parameters, meteorological parameters (hydrology and hydro-geology)
- (d) Layout of the nuclear power plant buildings and equipment, in particular, physical separation, easy accessibility to equipment for maintenance and routine surveillance, shielding and protection against explosions, missiles, plane crashes, fire and other natural and man-induced events.
- (e) Nuclear security giving emphasis to physical protection system design.

5.3.2.2 Building and Structures

- (a) Reactor Building
 - (i) Layout

- (ii) Functional and safety requirements of containment structures, internal structure, calandria vault, vent shafts, distribution headers and air-lock barrels.
 - (iii) Containment pressure, leak tightness, provisions for conducting proof test, leakage rate tests including instrumentation for structural monitoring and leakage rate tests.
 - (iv) Containment pressure suppression system, separation of high and low enthalpy volumes and pressure equalisation within RB.
 - (v) Design basis and design requirements including foundation design, analysis methodology and modelling, strength, serviceability and shielding requirements, seismic design and fire protection.
 - (vi) Specific design basis and design requirements for bulk shielding, penetrations through structures designed for shielding and layout of radioactive systems/components/equipment in building areas/rooms.
 - (vii) Loads and load combinations, materials and material properties.
 - (viii) Construction, maintenance and in-service inspection aspects
 - (ix) Decommissioning aspects.
- (b) Spent Fuel Storage Building
 - (i) Layout
 - (ii) Functional and safety requirements
 - (iii) Radiation zoning aspects
 - (iv) Items (v) to (ix) of (a) above.
 - (c) Service Building
 - (i) Layout
 - (ii) Functional and safety requirements
 - (iii) Radiation zoning aspects
 - (iv) Items (v) to (ix) of (a) above.
 - (d) Other buildings and structures important to safety
 - (i) Items (i), (ii) and (iii) of (b) above and (v) to (ix) of (a) above.

5.3.2.3 Process Systems

- (a) Reactor Core
 - (i) Physics and thermal-hydraulics, including reactivity balance, kinetics and spatial power distribution

- (ii) Fuel and structural component design and behaviour
 - (iii) Moderator and cover gas system
 - (b) Systems for control of reactivity and of spatial power distributions
 - (c) Reactor coolant systems, in particular their physical boundaries (i.e. pipe walls, pressure vessel walls, valve bodies)
 - (d) Instrumentation and control
 - (e) Energy conversion systems
 - (f) Re-fuelling mechanisms, fuel handling and storage
 - (g) Electrical systems
 - (h) Plant auxiliaries
 - (i) Radioactive effluents and waste management
 - (j) Ventilation system
 - (k) Ultimate heat sink and its directly associated heat transport systems
- 5.3.2.4 Safety Systems
- (a) Protection systems and safety actuation systems
 - (b) Emergency cooling systems and other engineered safety features
- 5.3.2.5 Other Design Provisions
- (a) Maintenance and maintainability
 - (b) Radiation protection
 - (c) Physical security relevant to safety (to be treated on a confidential basis)
- 5.3.2.6 Safety Analyses by the Applicant
- (a) Analyses of safety during normal operation including estimates of radioactive effluent releases
 - (b) Analyses of anticipated operational occurrences and postulated accident conditions
- 5.3.2.7 Quality assurance program for design and construction
- 5.3.2.8 Provision for industrial safety including fire safety and safety of contractor workers
- 5.3.2.9 Qualification and organisation of the applicant and his vendors
- 5.3.2.10 Provision for in-service inspection including systems and equipment.

5.3.2.11 Provision for decommissioning as per AERB Safety Manual on Decommissioning of Nuclear Facilities (AERB/SM/DECOM-1)

5.3.3 Reactor of New Concept or First of its Kind

For a reactor of new concept or first of its kind, the construction consent may be sought at the time when details of the design are being developed. Also, a detailed design review by the regulatory body may require a longer time frame as compared to normally sought construction clearance. Where the utility requires expeditious issue of consent for construction it shall submit in addition to complete SAR (P), a concise document bringing out all items that are safety related and those that are irreversible, so that regulatory body may review the same for grant of construction clearance for a sub-stage of construction. In such situation, the remaining design and safety review would continue in parallel with the ongoing construction activity. This would allow sufficient time for review of detailed design and related safety aspects.

Consequently, as suggested in section 2.2.3 and 2.3.3, the construction consent may be issued as clearances for three sub-stages. The submission for each of these sub-stages may be selectively done as suggested in section 3.22, and the review and assessment areas of particular significance may be as described in Appendix-9.

In case the applicant desires that a single consent for entire construction stage is required even for reactor of new concept or first of its kind, then AERB would consider the same, provided that the complete SAR (P) along with additional/supporting documents, as required, are satisfactorily reviewed towards granting of construction consent. The lead-time schedule for submission of documents given in Section 3.22 is indicative, but it would depend upon the technical input made available for review.

Appendix-6 gives the typical levels of safety review for construction stage.

5.3.3.1 Regulatory Clearances for Sub-stages

(a) Excavation

This implies clearance for ground excavation for laying foundations of buildings/structures of main plant area. Normally, this clearance is given for the entire main plant work and laying of plain cement concrete mud-mat for the foundations is considered as part of this sub-stage.

For this sub-stage, review will be limited to general description of plant, safety and seismic classification, site related data, layout of main plant buildings and related facilities, general design criteria for civil, mechanical, electrical, instrumentation, safety and safety related

system design. More emphasis may be given for review of plant layout and building foundation requirements (design criteria) and other general safety related facilities like safety organisation, first aid, fire safety, etc. PDSC and CESC may review the implementation of all safety aspects related to siting and excavation (Details are covered in items 1, 2 & 3 of Appendix-9). SAR(P) chapters related to siting, building layout and general design criteria, including those for design of bulk shielding, penetrations through shielding and layout for rooms/ areas containing radiation sources (systems/components/equipment) requiring shielding, must be completely reviewed by PDSC/CESC before clearing this stage.

(b) First Pour of Concrete (FPC)

This implies clearance for pouring of structural concrete for foundations and super structure of the buildings/structures of the plant. This clearance may be given for all buildings/structures or a group of buildings/structures in a phased manner if so desired by the applicant.

This sub-stage covers entire plant and hence design safety review of all major systems, structures and components must be completed before clearance for FPC. The review should cover the assessment of all safety-related buildings, radiation zoning, radiation shielding including bulk shielding, penetrations through shielding and layout of areas/rooms containing radioactive systems/components/equipment, all major reactor systems and plant services, radiological protection requirements and rad-waste management. In general, review should be completed for all chapters of SAR(P) related to reactor and safety, excluding only chapters related to conventional system (e.g. TG, services not related to construction safety), detailed safety analysis (accident analysis), organisation and administrative aspects, plant commissioning/operation, etc. The review should specifically cover the details of design safety aspects and those items, which are irreversible, i.e., which can not be modified later on, after the design is frozen and items are ordered/erected.

Normally, clearance for FPC implies commencement of first pour and continuation of the civil construction work for the relevant buildings/structures, unless there is any stipulation to the contrary which require permission of AERB, for continuation of work beyond stipulated point in terms of physical progress of the work and/or time period.

(c) Erection of Major Equipment

To give consent for this sub-stage, all the design related safety aspects

including safety (accident) analysis shall be fully reviewed and cleared by safety committees [The details of SAR (P) chapters, which are to be reviewed for this stage are covered in Appendix-9].

This implies clearance for erection/installation of the following major equipment/components:-

- Reactor vessel (i.e. calandria for PHWRs, reactor pressure vessel for PWRs and safety vessel for FBRs)
- Pumps, steam generators and pressuriser of reactor coolant system
- C & I modules of reactor regulation system, protection system and engineered safety features

Equipment of other safety and safety-related systems can, however, be erected/installed after completion of the required safety review of the same in parallel with earlier sub-stages of construction consent (viz. FPC).

Submissions of reports along with technical supporting documents should be made, well in advance, for satisfactory review prior to grant of authorisation for equipment erection. The important (typical) areas/topics to be covered are:

- Validation of computer codes used design and safety evaluation
 - Equipment qualification and its acceptance criteria
 - Safety significant observations made during manufacture of safety related structures, equipment and components
 - Pre and post installation preservation methods for safety related equipment and components
 - Operating experience feedback
 - Basis of acceptance for innovative (first of its kind) systems
- Additional notes on areas/topics, if considered important for safety review by PDSC/CESC/ACPSR should also be addressed for review as per Sections 4.3 & 4.4.

PDSC/CESC after completing its review will submit its full report including status of implementation of earlier recommendations, to ACPSR, which after its review will submit to AERB for the issue of the consent.

5.4 Regulatory Consent for Commissioning

Commissioning activities in NPP/RRs are initiated in parallel to construction

during its later period. Various equipment and systems are individually commissioned as and when the prerequisites for their commissioning are met. The first regulatory clearance within the commissioning consent, however, is required when the applicant desires to initiate the integrated commissioning activity, e.g. hot conditioning for PHWR. Following this, there are a number of intermediate commissioning stages at which too regulatory clearances are required. These stages act as check points where the results of previous activity and prerequisites for further activity are reviewed till the plant is brought to operational state. Appendix-7 gives the typical level of safety review for intermediate commissioning stages.

5.4.1 Commissioning of Plant Components and Systems

It is important that an adequate program for the commissioning of plant components and systems is developed and this be reviewed and assessed by AERB.

Review and assessment areas of particular importance are:

- (a) Final as-built design of the plant components and systems
- (b) Quality records (such as construction completion certificate, history docket, etc.) after construction of the plant components and systems, and the program for their operation.
- (c) Pre-service examination
- (d) Adequacy of organisation and qualification of the operating personnel
- (e) Operational limits and conditions
- (f) Operating instructions and procedures for commissioning and operation of the plant.
- (g) Nuclear security aspects.

The submission of these documents should conform to section 3.22 of this guide. The details of the documents to be reviewed in this category are given in Appendix-4. Before consent for commissioning of these components and systems is issued, their final 'as-built' state, should be reviewed and assessed. Conformance of their construction with the design and regulatory requirements should be verified, changes should be evaluated, the test program should be approved, and their operating limits and conditions should be reviewed and assessed by AERB.

5.4.2 Regulatory Clearance for First Approach to Criticality and Low Power Physics Experiments

Commencement of operation is defined as the approach to the first criticality. This is a major step in the consenting process. The review and assessment shall consider the final or 'as-built' design of the nuclear power plant as a

whole. AERB should satisfy itself that the plant has been built in accordance with the accepted design, and meets all the regulatory requirements, that the required level of quality has been achieved and that the safety review and assessment of all relevant systems including required tests have been satisfactorily completed. Details of documents to be reviewed in this category are given in Appendix-4.

Areas of significance requiring review and assessment are:

- (a) Final design of the plant as a whole including all areas listed under (1) to (4) in sub-section 5.3.2)
- (b) Safety analyses by the applicant, including evaluation of changes in design subsequent to previous consent.
- (c) Quality records after manufacture/construction, and quality assurance program for operation
- (d) Adequacy of applicant organisation and qualification of the site personnel: This concerns their responsibilities and competence, and is particularly aimed at the authorised operating personnel
- (e) Commissioning program
- (f) Operational limits and conditions (revised as necessary)
- (g) Operating instructions and procedures
- (h) Radiation protection program
- (i) Emergency plans
- (j) Waste management
- (k) Nuclear security aspects

5.5 Regulatory Consent for Operation

5.5.1 Before Start of Operation

Before consenting for routine operation, AERB should review and assess the results of commissioning tests for their consistency with design information, and with the prescribed operational limits and conditions. Any inconsistency should be resolved to the satisfaction of AERB. Following additional areas should also be reviewed prior to consenting for routine operation:

- (a) Surveillance, Periodic testing, maintenance and in-service inspection programs.
- (b) Re-training program for operating personnel

5.5.2 During Operation

During operation AERB shall, as necessary, satisfy itself that the plant is

operating within operational limits and conditions and in particular that the radiological protection of the site personnel, the public and the environment, is being maintained. This involves the following:

- (a) A continual appraisal of information available from:
 - (i) Operational results and abnormal occurrences
 - (ii) Regulatory inspections
 - (iii) Environmental survey and monitoring
 - (iv) Experience gained from this and similar plants
- (b) Special reviews and assessments in the case of events such as:
 - (i) Significant abnormal occurrences and accidents at the plant itself
 - (ii) Significant abnormal occurrences and accidents at a similar plant
 - (iii) A proposed change in operational limits and conditions, in operating instructions and procedures, or in the plant itself, that is relevant to safety
 - (iv) Changes in the surroundings that may affect safety
- (c) Periodic review and assessment of safety in the form of:
 - (i) Renewal of authorisation every five years
 - (ii) Periodic safety review (PSR) every ten years.

5.5.3 For such a continual appraisal or for such special reviews and assessments, during operation, various operational safety aspects, such as adherence to operational limits and conditions, review of plant performance, abnormal occurrences, radioactive releases to the environment, radiation exposures, effluent management, technical and procedural modifications, industrial safety, etc. should be taken into account. (Refer AERB safety guides on Regulatory Inspection and Enforcement in Nuclear and Radiation Facilities, AERB/SG/G-4 and AERB safety guide on Maintenance of Nuclear Power Plants, AERB/SG/O-9). For renewal of consent, comprehensive periodic safety review of the plants is required considering cumulative effects of plant ageing and irradiation damage, results of in-service inspection (ISI), system modifications, operational feedback, status and performance of safety systems and safety support systems, revisions in applicable safety standards, technical developments, manpower training, radiological protection practices, plant management structure, etc. Review for periodic renewal of consent will be carried out in accordance with AERB/SG/O-12 : 'Renewal of Authorisation for Operation of Nuclear Power Plants'.

5.6 Regulatory Consent for Decommissioning

The procedures and the conditions to be followed during decommissioning, and the final state of the plant should be reviewed and assessed. (Refer AERB Safety Manual on Decommissioning of Nuclear Facilities, AERB/SM/DECOM-1).

Areas of particular significance are:

- (a) Quantity and nature of radioactivity in the plant at the end of its operation
- (b) Procedures and methods applied in decommissioning
- (c) Final state of the plant after decommissioning
- (d) Physical security relevant to safety, radiological surveillance of the site and its environment, if necessary, after decommissioning.

5.7 Reassessment due to New Information

During the review and assessment process, additional information in such form as test results, research and development results, operating experience including incidents and accidents, changes in off-site conditions may become available in an area that has already been reviewed and assessed. If the applicant becomes aware of any such additional information, it shall be his responsibility to accordingly inform AERB and promptly forward the relevant documentation. He should also present analyses regarding the safety significance of this information. Where such information might be significant with respect to plant safety, AERB shall re-review and reassess the affected area and, if necessary, ask for required modifications in order to achieve an adequate level of safety.

AERB may, in the light of such new information, modify its regulations or issue new guidelines that might affect areas of a plant for which approval has already been granted. AERB should perform a review and assessment of previously approved plants to determine whether there is a need to apply such new regulations and guidelines.

6. METHOD OF REVIEW AND ASSESSMENT

6.1 General

The review and assessment process is performed by AERB, based on the information submitted by the applicant to demonstrate the safety of the plant. The analysis of this information enables AERB to make a decision or series of decisions on the acceptability of plant in terms of safety. The process consists of examining the applicant's submissions on the safety of the plant. It includes consideration of both normal operation and failures, design basis events including human error that have the potential to cause the exposure of workers or the public, or subject the environment to radiation hazard. The submissions by the applicant should be as complete as possible and one of the initial tasks of the review and assessment process is to confirm that this is so. The review and assessment process includes checks on the actual situations at the site and elsewhere to validate the claims made in the submissions.

The review and assessment of nuclear security aspects will be performed by AERB on a confidential basis.

The main tasks in this process are:

- (a) To determine the radiological consequences to site personnel, the public and the environment, arising from normal operation and anticipated operational occurrences and to evaluate the adequacy of the associated protection measures in design and operation.
- (b) To determine the risks posed to the site personnel, the public and the environment by postulated accident conditions, and to evaluate the adequacy of the associated prevention and protection methods.
- (c) To determine the risk of adverse impact due to unauthorised removal of nuclear material and/or sabotage of NPP and assess the adequacy of measures taken to minimise the risk.

Anticipated operational occurrences should not result in radiological doses beyond prescribed limits. In case of accident conditions within design basis, the radiological doses should not exceed the acceptable limits. For mitigating effects of events beyond DBE, emergency plans should be available.

6.2 Approaches to Review and Assessment

- 6.2.1 The scope and depth of review and assessment will depend on several factors, such as novelty, complexity, previous history, the experience of the applicant and the associated risk.
- 6.2.2 Much of the effort that AERB makes during the review and assessment process

is concentrated on performance of a step by step review and assessment procedure to determine whether the applicable safety objectives and requirements on each aspect of the topic have been met. This stage of the process consists in examining the submissions from the applicant on his managerial arrangements, engineered systems, operational procedures and the safety analysis of the plant. This analysis would cover all DBE conditions to demonstrate that the safety of the plant meets the safety objectives and requirements prescribed by AERB. AERB would determine whether these submissions have provided a sufficiently complete, detailed and accurate demonstration. In carrying out the review and assessment, AERB may find it useful to perform its own analyses, or even to commission research. Any input of this nature by AERB would not in any way compromise or diminish the applicant's responsibility for the safety of the plant.

6.3 Use of Reference/Generic Submissions

- 6.3.1 The submissions to be made by the applicant, for various consenting stages, have been identified in section-3. Where submissions for a particular type of plant (or parts there of) may be repeated many times, it may be acceptable if the applicant provides a submission on reference or generic plant. For this purpose, previously reviewed and consented plant may be identified by the applicant as the reference plant.
- 6.3.2 It would be inappropriate to give full consent for the reference or generic plant, since safety depends on factors such as siting, managerial and operational aspects, which will only become apparent when a specific applicant requests consent in relation to a specific site. The consideration will be limited to the generic design, which should be followed by supplementary submissions by the applicant, for the specific plant.
- 6.3.3 Given that the review and assessment by AERB has been completed satisfactorily and AERB has accepted the generic or reference plant or design, the applicant would then have to make only a limited submission for each specific plant. This submission should then concentrate on those aspects or features for which the specific plant differs from the reference or generic one, and in particular those features that are particular to the chosen location or site. In providing such a submission, the applicant should clearly indicate which aspects of the reference or generic submission are affected by the specific plant, and should provide an explanation of why the aspects of the submission are not affected. In addition, AERB, in its comments on the generic or reference plant, may have set out particular aspects that it would wish to see addressed in the specific submission.
- 6.3.4 AERB should perform its own independent review and assessment, even if the plant has been considered consentable by regulatory body of another country. AERB, however, may take into account the review and assessment

by the other country, and new experience and knowledge that have been gained since that review and assessment. It may also be necessary to take account of the differences in safety standards and requirements between the two countries.

6.4 Codes and Guides as Reference Documents

The information and documents to be submitted by the applicant, along with his applications for consent at various stages, and the requirements he has to comply with, are spelt out in the codes on the subject accepted by AERB. Details are furnished in the guides issued by AERB.

These codes and guides will be useful to the applicant/consentee while complying with the requirements, and to AERB while reviewing and assessing the status. Appendix-8 lists the relevant AERB codes and guides.

6.5 Direction of the Review and Assessment Process

AERB may constitute safety committees/expert bodies for review and assessment, in respect of a given plant.

For follow-up of the assessment process, it may designate a group possessing broad technical ability to conduct the following tasks:

- (a) Collecting and recording the relevant documents provided by the applicant.
- (b) Coordinating the review and assessment process.
- (c) Collecting and synthesising assessments carried out by safety committees constituted by AERB, consultants and advisory bodies.
- (d) Based on the recommendation of the review, drafting the stipulations for issuing the consent.

In general, a three tier review process is followed by AERB before any activity is consented to in a nuclear power project/plant. Details of this process are given in Section 2.3 for projects and for operating plants.

6.6 Basis for Decisions

At many stages during the review and assessment process, decisions are taken on the acceptability of various aspects of the plant. The nature of these decisions will vary during the life cycle of the plant and some will be associated directly with stages of the regulatory consenting process. AERB recognises the basis for such decisions, which takes into account of a number of factors. Important among these are:

- (a) the extent to which the safety objectives and requirements have been fulfilled;

- (b) the acceptability of the depth and detail of the applicant's submission, keeping in view the nature of the plant and the potential risk it presents;
- (c) the state of knowledge with respect to particular processes or effects; and
- (d) the confidence in the conclusions reached as a result of the analysis of the situation.

These factors are an integral part of the review and assessment process and receive special consideration in the documentation produced by AERB. The decisions on acceptability are taken against a background of safety objectives, precedents and judgments, the basis for which should be clearly understood. The decision to accept a plant, for example, will always be taken in the light of a requirement to fulfil certain obligations, which will include, for example, operational limits and conditions and obligations relating to the maintenance program and the frequency of in-service inspection.

6.7 Conduct of Review and Assessment

6.7.1 In carrying out its review and assessment, AERB determines whether the applicant has defined criteria:

- related to engineering design,
- related to operational and managerial aspects, and
- for normal and DBE conditions which meet the safety objectives and requirements.

The safety objectives and requirements should cover, among other things:

- emphasis on prevention of DBEs rather than on mitigation of their consequences;
- application of defence in depth principle;
- the single failure criterion;
- requirements for redundancy, diversity and segregation;
- the preference for a passive over an active or operator based prevention and protection system;
- criteria related to human factors and human machine interface;
- dose limits and dose constraints (both occupational and public) and discharges to the environment;
- minimisation of waste generated, including the future decommissioning phase.
- minimising the risk of unauthorised removal of nuclear material and/or sabotage of NPP

- 6.7.2 The general aim of safety analysis, whether deterministic or probabilistic, is to verify that for each identified barrier, the safety measures are sufficient at the following three levels, providing a progressive character for the safety analysis:
- (a) prevention of failure of the barrier itself and prevention of failure of related systems during normal and DBE conditions.
 - (b) monitoring of any parameter significant to the integrity of the barrier, to allow initiation of either manual or automatic actions in order to prevent any evolution towards an unsafe condition.
 - (c) safety action preventing or limiting release of radioactive material if the barrier has failed.

For certain applications, depending on the associated risk, the safety measures for mitigation of consequence should be reviewed.

- 6.7.3 From the safety analysis, the safety requirements on structures, systems, components (SSCs) and operations can be derived and compared with the provisions made by the applicant. The review and assessment by AERB ensures that the applicant has used the safety analysis to determine these requirements and that the requirements are met in the equipment and operational procedures. Specific features that are subject to review and assessment include:
- (a) safety functional requirement of SSCs;
 - (b) quality of engineered features in terms of good engineering practice or as set out in the regulatory requirement;
 - (c) control of the facility under normal conditions and DBE conditions, taking into account the automatic systems, the man-machine interface and operating instructions;
 - (d) quality assurance covering SSCs and operational aspects such as training, qualification and experience of the applicant's personnel and the safety management system.

6.7.4 Organisation and Management

Even a well engineered plant may not achieve the required level of safety if it is not managed well. The review and assessment by AERB, therefore, includes consideration of the applicant's organisation, management, procedures and safety and security culture which have a bearing on the safety of the operation of the plant. The applicant should demonstrate by documentary means that there is an effective safety management system in place which gives nuclear safety and security matters the highest priority.

Specific aspects which are subject to review and assessment include:

- Whether the applicant's safety policy emanates from senior management and shows commitment at a high level to safety requirements and the means by which these will be achieved.
- Whether the applicant's organisation is such that it can implement the commitments made in the safety policy, through existence of adequate procedures, practices and organisational structure.
- Whether the applicant has procedures to ensure that there is adequate planning of work, with suitable performance standards, so that staff and managers know what is required of them to meet the aims and objectives of safety policy.
- Whether the applicant has a system in place to periodically audit its safety performance.
- Whether the applicant has procedures in place to review periodically all the evidence on its safety performance in order to determine whether it is adequately meeting its aims and objectives and to consider where improvements may be necessary.
- Whether the applicant has culture, commitment, organisation, systems and procedures, to meet the nuclear security requirements.

The review and assessment by AERB covers all aspects of the applicant's managerial and organisational procedures and systems which have a bearing on nuclear safety such as, operational feedback, compliance with operating limits and conditions, planning and monitoring of maintenance, inspection and testing, production of safety documentation, and control of contractors.

6.7.5 Radiological Consequences under Normal Conditions

The review of provision for routine operation is directed towards the determination of occupational doses and radioactive discharges to environment. These results will be compared with the limiting requirements prescribed by AERB. The regulatory review and assessment of the applicant's submission determines whether it satisfies these requirements and objectives. In the review and assessment, particular attention is devoted to a number of topics that influence the potential radiological consequence to the workers, the public and the environment during routine operation, which include:

- (a) sources and inventory;
- (b) occupational radiation exposure;
- (c) radiation protection of the public, with all pathways taken into account;
- (d) radioactive waste management; and
- (e) discharge, dilution and dispersion of radioactive effluents.

AERB may also verify whether reasonably achievable improvements in the

design or operating procedures of the plant have been carried out with the aim of further reducing potential radiological consequences, in line with the ALARA principle.

6.7.6 Safety Analysis of DBE Conditions

Consideration of DBE conditions strongly influences the design limits for the safety systems and for most SSCs needed for the operation of the plant. It will also strongly influence the operational instructions and procedures that operating personnel should follow. In addition, the potential radiological consequences for workers, the public and the environment in DBE conditions may be much more severe than those during routine operation. For this reason, a large part of the review and assessment effort may be expected to be directed to the safety analysis of DBEs provided by the applicant. Safety analysis can be considered in two major steps:

- (a) identification of postulated initiating events (PIEs) and their frequencies; and
- (b) evaluation of how these PIEs develop and their consequences.

Identification of Postulated Initiating Events

The review and assessment process considers whether the applicant's list of PIEs is acceptable as the basis for the safety analysis (refer AERB/SG/D-5 for the list of PIEs to be considered for PHWR of current design).

Analysis of Postulated Initiating Events

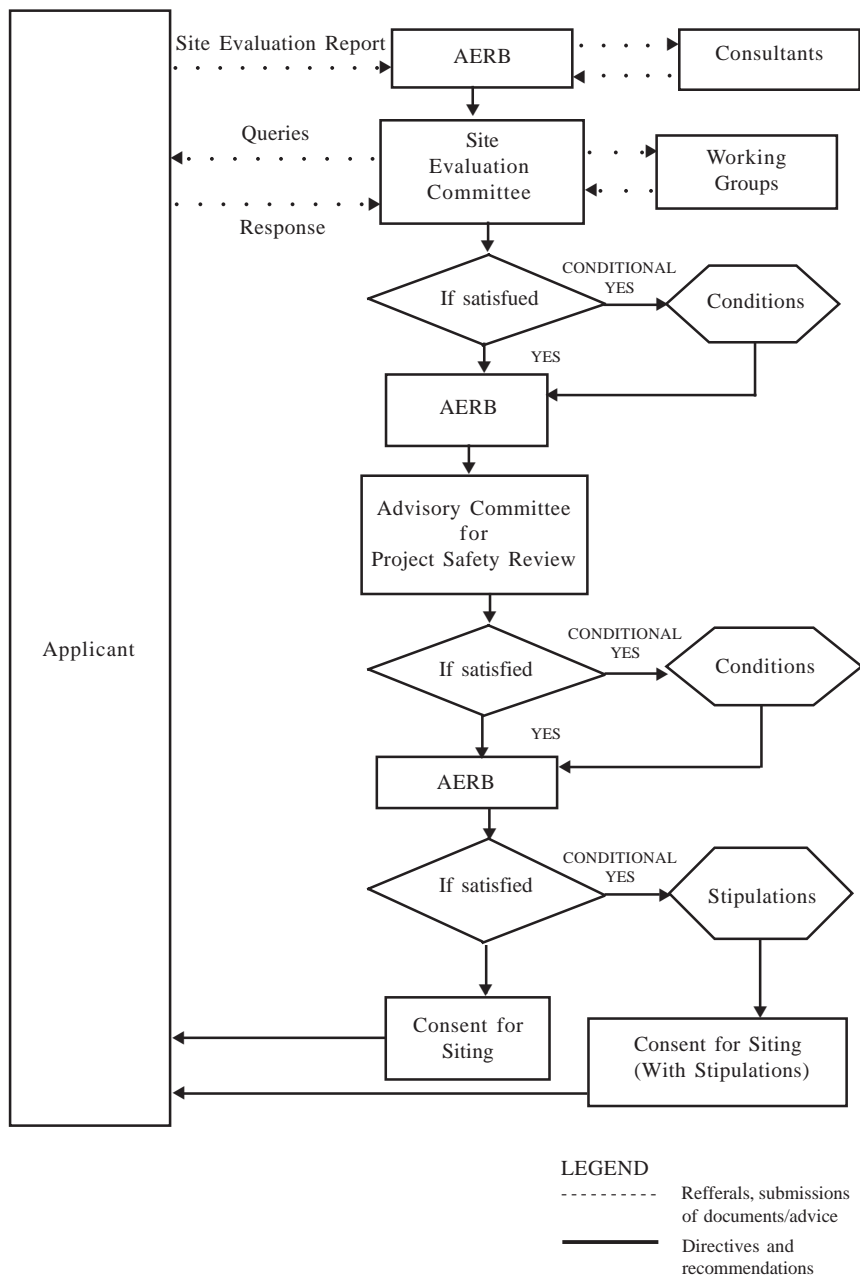
- (a) AERB determines the type of analytical considerations and assumptions to be used in its review and assessment of the applicant's analysis, and checks that these have been taken into account and are in conformance with applicable safety guides. It is often the case that for those PIEs which may govern the design and provision of safety systems, or which affect the safety requirements on engineering SSCs, a high degree of conservatism is required in the analysis to meet the requirement of demonstrating that the safety of the plant is robust. AERB, as part of its review and assessment, ensures that the input and assumptions made in the safety analysis are in line with the actual design and operating practices. Similarly, the engineering systems should be qualified to meet the functional requirement for which they were designed, under all situations considering environmental conditions, ageing, etc.
- (b) The analyses of DBE conditions and long term safety are usually performed using computer codes. The regulatory review and assessment includes a check that any data, modelling or computer codes used in calculating either the performance of equipment under

the conditions indicated by the analysis or any radiological consequences, are based on sufficiently well founded knowledge and understanding, and that an adequate degree of conservatism has been employed. As part of its review and assessment, AERB ensures that the computer codes are based on well understood principles. Computer codes are validated against experience or experiment that the coding has been done accurately and the input data have been correctly assigned. In many cases the codes would have been used widely both nationally and internationally, and so it will be possible to consider their verification and validation on a generic basis. However, checks are made to ensure that the code has not been corrupted by modifications and is being used in an appropriate manner.

- (c) It has been emphasised previously that in the regulatory review and assessment, it is checked that the claims made in the applicant's submission are accurate. In considering the safety analysis, it is important that these checks include the manner in which operations are carried out, the availability of standby equipment and personnel, the range of normal operational modes, as well as the performance of obvious items of equipment. These checks also ensure that the identification of faults and hazards has been accurate, since some possibilities of common mode effects or causes, due to internal hazards for instance, may not be apparent until the actual physical layout is observed. The layout may also limit claims for operator intervention, if systems are difficult to access owing to their position. In considering this aspect, the fact that access by the operator is necessary because of DBE condition is to be borne in mind.
- (d) Further to the deterministic approach, safety analysis should be performed with probabilistic approach, and progressive use of this probabilistic approach should be made as required for risk-informed regulatory decision making. PSA uses a best estimate approach. The confidence in the PSA results should be supported by uncertainty analysis, importance measures and sensitivity studies. Annexure-1 gives general guidelines for review and assessment of PSA.

6.7.7 Design Basis Threat and Assessment

The systems should be designed based on the design basis threats identified and analysis should be carried out in order to assess the risk of unauthorised removal of nuclear materials and/or sabotage of NPP and incorporation of corrective measures.



**FIG. 2.1: SCHEME FOR CONSENT FOR SITING
(Ref. Section 2.3.3 (a))**

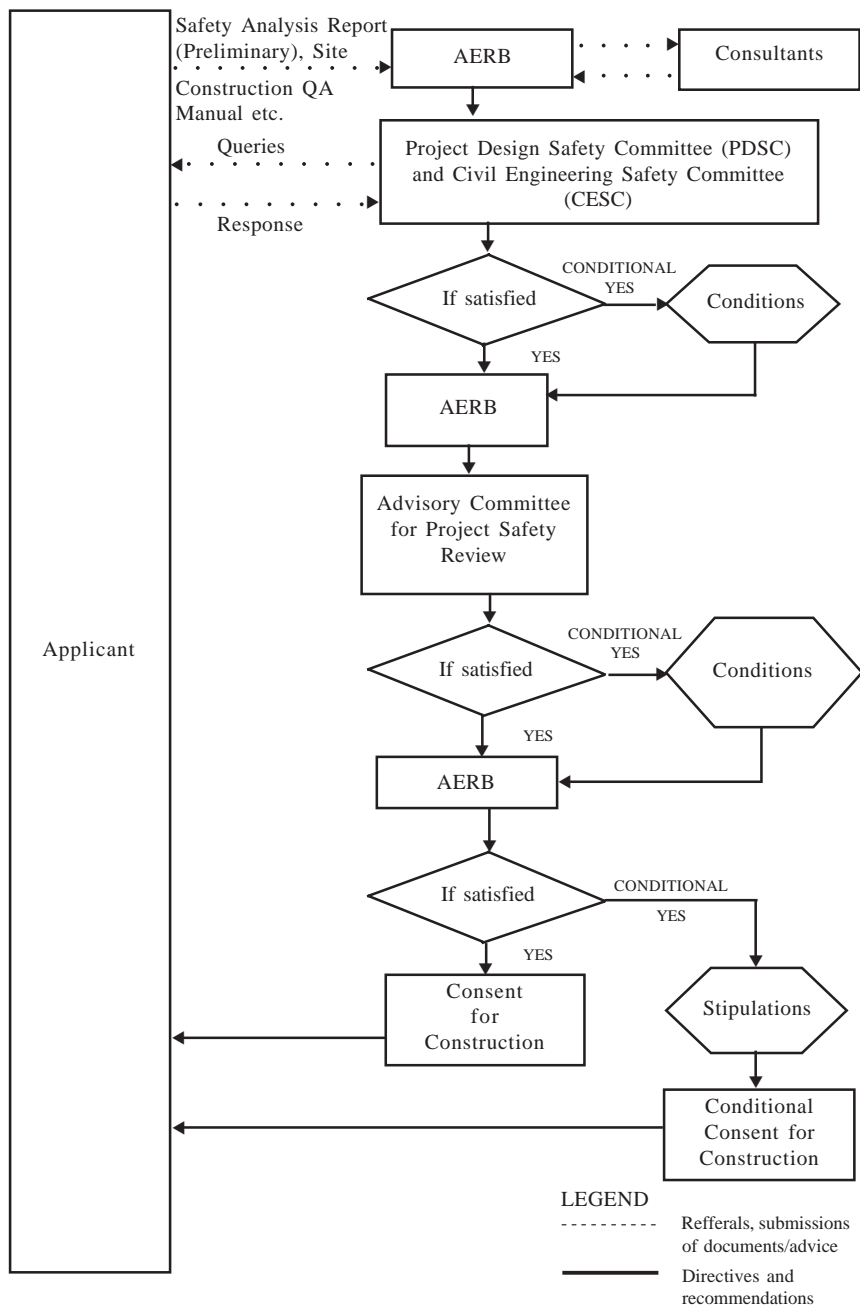


FIG. 2.2: SCHEME FOR CONSENT FOR CONSTRUCTION (Ref. Section 2.3.3 (b))

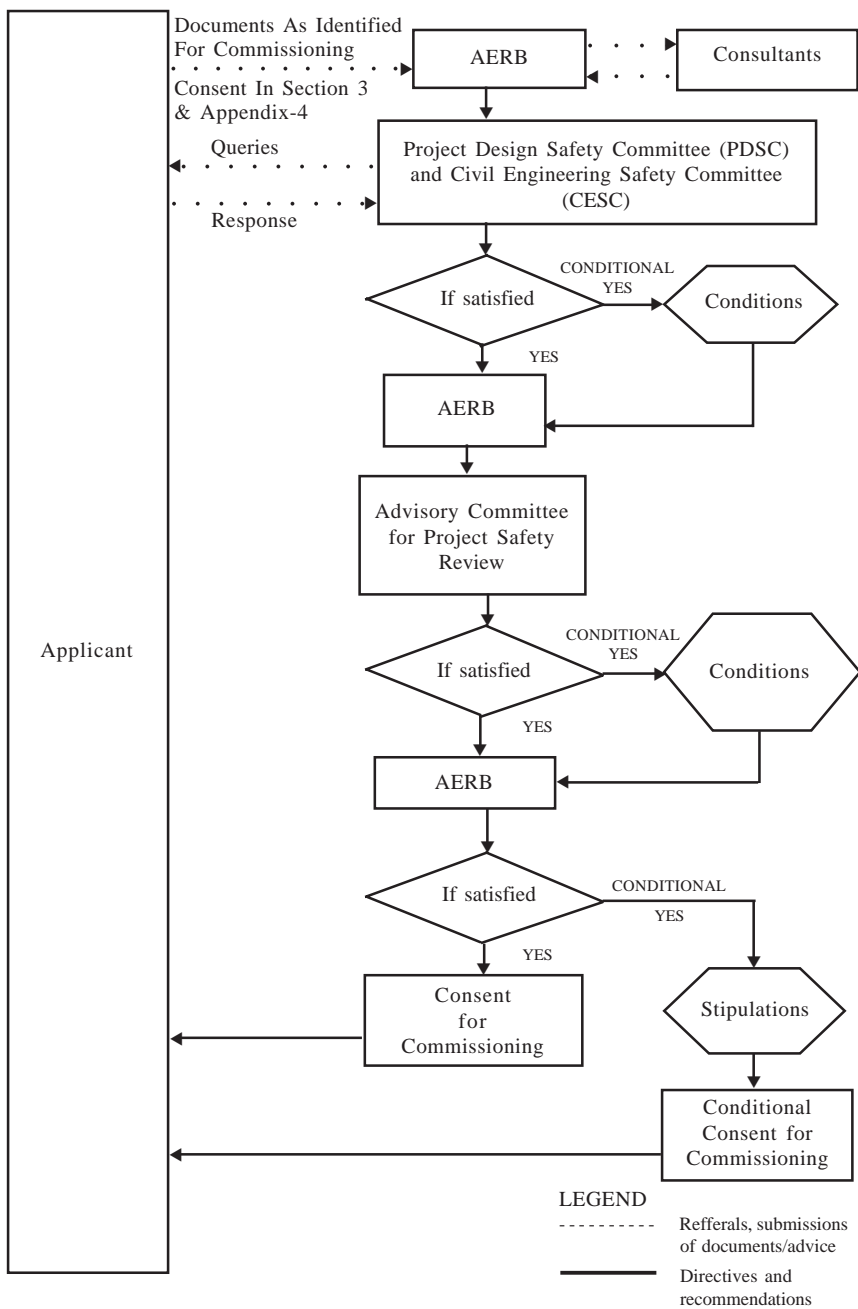


FIG. 2.3: SCHEME FOR CONSENT FOR COMMISSIONING (Ref. Section 2.3.3 (c))

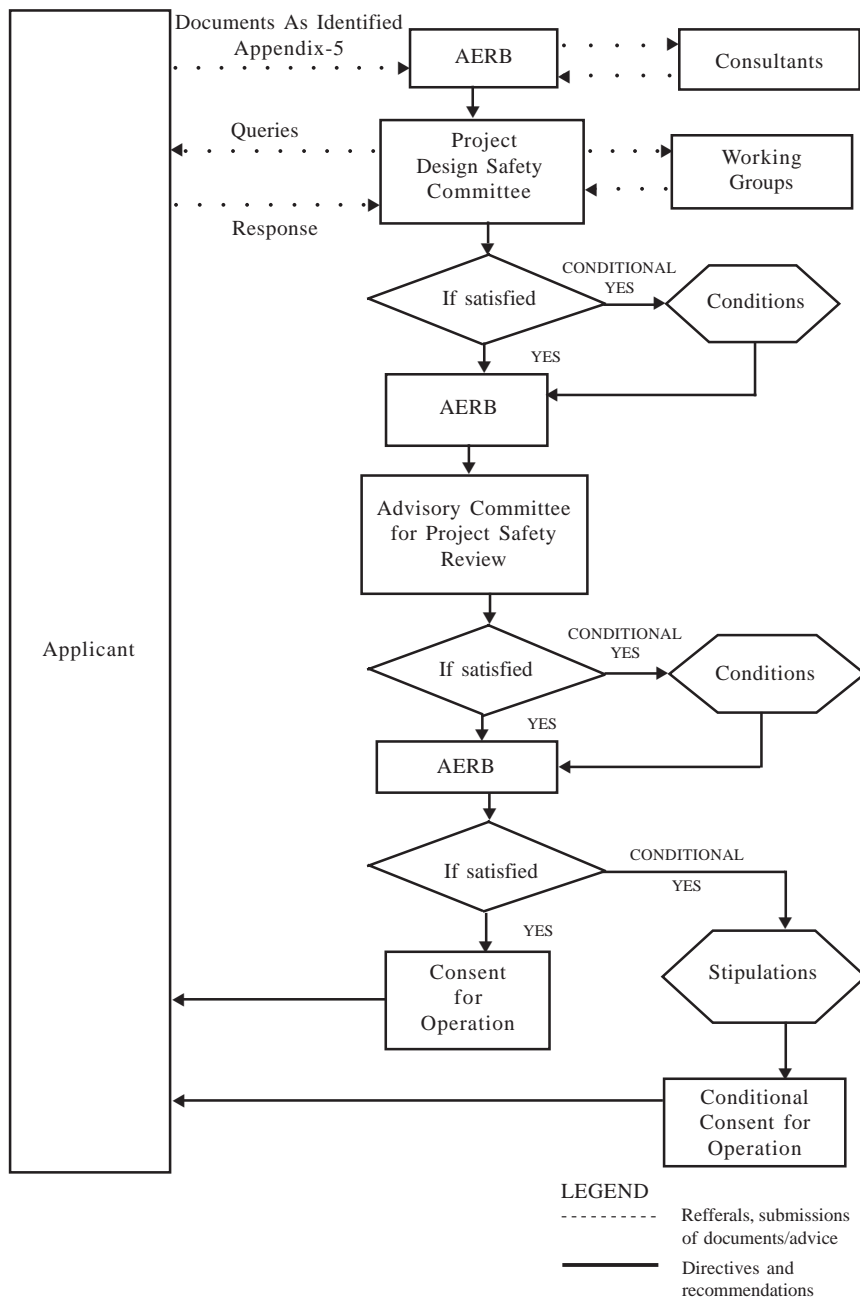


FIG. 2.4: SCHEME FOR CONSENT FOR OPERATION (Ref. Section 2.3.3 (d))

APPENDIX-1

(Refer Section 3.2)

CONTENTS OF SITE EVALUATION REPORT-TYPICAL

1. Guidelines on the Contents of the Site Evaluation Report for NPP

The contents of the site evaluation report (SER) should cover various items under following broad category.

- (a) Salient features of the proposed site
- (b) Site characteristics affecting safety
- (c) Interactions of NPP with its environment

A detailed description on these requirements is given in Code of Practice for Safety in Siting of Nuclear Power Plants, AERB/SC/S, and safety guides issued under the Code. The basic data required for site evaluation process is given in Annexure-C of AERB siting code.

In addition, SER should contain brief design information on the proposed project. It should provide concise information giving an overview of the proposed power plant. The information should assist in evaluating the given site in relation to the type, capacity, number of units etc. It should include following information.

- (a) proposed type of plant including capacity of plant, number of units, etc.
- (b) overall safety approach
- (c) dose limits, bases for emergency preparedness
- (d) offsite power supplies

The contents of the information on the following subjects, to be included in the SER, are discussed herein after in this Appendix.

- (i) Geography, demography and topography
- (ii) Meteorology
- (iii) Hydrology and hydro-geology
- (iv) Geology
- (v) Seismology
- (vi) Radiological impact covering environmental impact assessment (EIA) aspects
- (vii) Thermal pollution
- (viii) Design information on the proposed project
- (ix) Nuclear security

1.1 Geography, Demography and Topography

The site and its location should be described with the aid of maps of suitable scale. The present and foreseeable uses of surrounding land should be described. Data on food/milk production and on dietary habits in the area should be compiled, with special attention to food processing or any other sensitive industry.

Existing or planned industrial and public facilities in the neighborhood such as roads, railways, waterways, transport of dangerous goods, chemical plants, military installations, gas pipelines, airports, archaeological monuments, parks and places of pilgrimage, including anticipated changes in their utilisation should be described in such a way as to facilitate the evaluation of the risks which they may pose to the nuclear power plant or the risk the NPP may pose to these facilities.

The current and forecast population of permanent residents in the surrounding area, including those in schools and hospitals, should be tabulated as a function of distance and direction in such a way as to demonstrate the feasibility of emergency plans to protect the population against the accidental release of radioactivity. Similar information should also be given for transient and seasonal population.

Access to the site should be discussed where it may influence outside intervention in case of emergency, ease of evacuation of personnel or members of the public, or hazards associated with the shipment of irradiated fuels or radioactive waste.

The topography of the surrounding area and the site should be discussed from the viewpoint of meteorology, hydrology, geology and seismicity.

1.2 Meteorology

Meteorological conditions having an influence on the consequences of normal and accidental releases of radioactive materials should be described and discussed. The influence of cooling towers on the behavior of atmospheric releases should also be included. In addition, the meteorological conditions affecting cooling systems should be described and discussed. The frequency of occurrence and possible consequences of extreme meteorological conditions such as tornadoes, hurricanes or typhoons, cyclones and precipitation should be discussed.

This information should include the distribution of wind velocity and direction, precipitation and atmospheric stability conditions. It should be explained how these data are dealt with in atmospheric diffusion and transport calculations actually presented in the application. The effect which meteorological considerations have in establishing design bases and operating conditions for the plant should be shown.

1.3 Hydrology and Hydro-geology

Information should be submitted, giving quantity and quality, about the water on, under and around the site. This information should include, in particular, sources of cooling water and their availability, ground water movement, river or lake current, dispersion conditions, potable and service water supplies. Attention should be given to the uses, present and projected, of water originating in or flowing through the area, taking into account possible contamination by the nuclear power plant in normal operation, anticipated operational occurrences and accident conditions.

Where applicable, the effect of natural phenomena such as tidal effects, floods and coastal cyclones should be evaluated. The consequences of failure of installations such as dams (up-stream and downstream) should also be evaluated.

1.4 Geology

Information should be provided on the geological formation of the site and its surrounding area and the effect it may have on the design of the foundations and structures. This information should include investigation of surface faulting, stability of sub-surface materials, and stability of slopes and embankments. Such features as geological anomalies and underground workings should be identified.

1.5 Seismology

Information concerning the seismicity of the site and its surrounding area, and the method followed for establishing the design basis vibratory ground motions, should be discussed, and the data given. This information should include a description of the behaviour of the ground during tremors in the past, a seismic history of the area, an indication and evaluation of active faults within a significant radius, and data on the seismotectonics of the site.

1.6 Radio-ecology

All necessary ecological data from the site and its surrounding area that are important for review and assessment of the radiological environmental impact of the nuclear power plant, such as biological systems and critical food pathways, should be presented. In case such data is yet to be generated, the program for the generation of the same may be given. In the mean time, conservative assumptions/approaches could be used with respect to the assessment of the radiological impact. The purpose is to get an assurance that the requirements regarding specified dose limits are met. A description should be given of the organisation and conduct of an environmental monitoring program to establish baseline data on radioactivity levels. This section should also cover aspects related to EIA studies.

1.7 Thermal Pollution

Thermal pollution resulting from discharge of warm water, steam and the cooling systems into the air and water body and the impact on ecosystem on account of above should be studied and reported. Wherever necessary, studies on thermal plumes should be conducted by constructing models. Where atmosphere is the ultimate heat sink, probable changes in local micrometeorology caused by cooling towers should be evaluated and report submitted.

1.8 Design Information on Project

1.8.1 General Design Criteria

- Safety objectives and principles (exception foreseen, if any, with respect to AERB regulation should be brought out.)
- Plant layout covering all anticipated units and facilities.
- Heat sink/water body its relation with maximum flood level.

1.8.2 General Description of the Proposed Plant

- Broad description of the type of reactor including information such as proven design/repeat design/new design.
- General aspects of reactor protection systems and engineered safety features to be used.
- Heat dissipation to environment.
- Off site and on site sources of power supply, sources of start up power, off site transmission network, power evacuation.
- Ultimate heat sink, its capacity to absorb heat, reliable availability of heat sink and agreements, if any, with appropriate local authorities.
- Waste management : objective, function and description.
- Environmental monitoring : program of environmental monitoring to be carried out at site, such as nature of soil and aquatic systems, meteorological/climatological data, land utilisation, natural and induced radioactivity content, population distribution, surface and subsoil movement, etc.
- Effluent release criteria : annual dose limit at fence post, applicable dose limits considering apportionment to various facilities at site and providing margin for future expansion etc. Apportionment for different routes viz. air route, aquatic environment and terrestrial route.
- Emergency preparedness : basis for emergency preparedness.

1.9 Site Characteristics with Reference to Nuclear Security

Site characteristics needed as input for identifying the design basis threat, location of main plant boundary, isolation zone and for design of physical protection system should be included.

2. Guidelines on the Contents of Site Evaluation Report for Research Reactor

The basis for the selection of a site for a research reactor will vary depending on number of factors including the design of the research reactor and its intended utilisation. Certain low power research reactors may impose minimal siting constraints. On the other hand, research reactors designed to achieve significant power levels (>1MW) and to be used for extensive experimental testing will impose full siting requirements as applicable to NPP. Therefore for low power reactors, which present very limited risks, the amount of details provided can be substantially less than what is required for a high power reactor. Generally, all clauses considered in Section-1, should be considered for research reactors and points, which are not dealt with in depth, should be brought out and fully justified.

APPENDIX-2

(Refer Section 3.3)

GUIDELINES FOR CONTENTS OF SAFETY ANALYSIS REPORTS FOR PHWRs

1. INTRODUCTION

1.1 General

This document gives guidelines for the organisation and contents of safety analysis reports for reactors. It is applicable primarily to PHWRs, but with suitable modifications, should also be applicable to other types of power, research, experimental and test reactors.

1.2 Format of Safety Analysis Reports

- (a) A table of contents should be provided. When a report consists of several volumes, at least an abridged table of contents should be included in each volume.
- (b) All information presented in drawings, maps, diagrams, sketches and charts should be legible, the symbols should be defined.
- (c) Abbreviations used should be consistent with the general usage and those not in general usage should be defined in each volume where they are used.
- (d) Removal and reinsertion of a page or pages and insertion of a modified page or pages should be easy.
- (e) Each safety analysis report should consist of sections, each section covering a particular system or topic. The discussion within a section should be reasonably complete and each section should be a self-contained part of the report. Tables and figures (including flow-sheets as applicable) should be included as required. Where necessary, cross references should be given.

1.3 Issue of Safety Analysis Reports

Safety Analysis Reports should be issued in two successive stages as indicated below:

- (a) Safety Analysis Report (Preliminary) : This should comprise a preliminary description of the facility and safety analysis based on the intended siting and design. Where any of the topics cannot be given full coverage at this stage, sufficiently detailed information (design bases, specifications, calculations) should be provided to

assess the feasibility of the plant at the proposed site, with regard to public health and environmental safety, before commencement of construction.

- (b) Safety Analysis Report (Final) : This should be the updated version of the safety report (Preliminary) with current and more specific information. It should also include detailed description of the operational aspects and safety of operating personnel.

1.4 Remarks

If items not discussed or included in any of the suggested sections are relevant to the safety of the plant, these should be included by insertion of additional sections or sub-sections. Similarly, if some of the sections are not relevant to the safety of the plant, these may be omitted. While normally the suggested format and coverage should be adhered to, at times there can be deviations to ensure systematic and logical presentation of information associated with the evaluation of individual safety aspects peculiar to the particular plant.

1.5 Definitions

- (i) Principal Design Criteria: These are the fundamental architectural and engineering design objectives established for the project, and represent the broad frame of reference within which the more detailed plant design effort is to proceed and against which the project will be reviewed.
- (ii) Design Bases: That information which identifies the specific functions to be performed by a major component or system in terms of performance objectives, together with specific values or range of values, chosen for controlling parameters as reference bounds or limits for design.
- (iii) Design Evaluation: A study of the functional and physical features of the major plant systems and components to determine:
 - (a) whether the design can or has met performance objectives with an adequate margin of safety, and
 - (b) the identity and susceptibility of failures, either in equipment or control over process variables, which could be possible initiating events for accidents.
- (iv) Safety Analysis: A study of the predicted response of the reactor plant to postulated initiating events, to determine with reasonable assurance whether the plant has capacity for preventing accidents or mitigating their effects sufficiently, to preclude undue risk to public health and safety.

2. CONTENTS OF SAFETY ANALYSIS REPORT

Safety analysis reports should be precise, lucid, clear and easily understandable. These should contain sufficient information to enable AERB to conduct a review of the safety analysis. Where necessary, further details on certain information can be given by reference to specific documents.

In terms of nature of content, there are two parts of the safety analysis report as follows:

Part-A: Design description, bringing out the design bases, safety aspects of the plant and data relevant for safety analysis.

Part-B: Safety analysis, giving an assessment of the consequences of postulated initiating events (PIEs) and event sequences against the acceptable safety criteria or probabilistic goals as may have been established, by the operating organisation and accepted by AERB, as applicable to the plant.

PART-A

(1) General Description of Plant; Safety and Seismic Classification

- Overall philosophy
- Overall plant summary description covering plant layout, reactor systems and auxiliaries and safety systems.
- Safety, seismic and quality classification of components, systems and structures; their bases, categories and tabulations giving detailed classification list.
- Overview of quality assurance in design, manufacture, construction, commissioning and operation.

(2) Siting and Environmental Data

This section should cover site characteristics that have influence on the design and operating plans of the NPPs. Data which have formed inputs for design basis parameters, e.g. seismic data, wind loads, flood levels, meteorological, geological and hydrological characteristics, population distribution and land use should be included.

The extent of the evaluation by the applicant and the amount and detail of information provided on any particular factor should be commensurate with the importance of that factor to safety.

Following may be covered:

- Site location : Geographical location indicating latitude,

longitude, distance/direction with respect to major towns/landmarks, location map, access roads/routes covering at least 50 km from the facility.

- Geological setting and tectonic set up; effect on design of foundation and structures.
- Seismic design basis, parameters covering the data base used, regional geology and tectonic, earthquake occurrence history. Applicable attenuation law for peak ground acceleration. PGAs for S1 (OBE) and S2 (SSE) levels, PGA response spectra and spectrum compatible accelerograms.
- Topography and ground-water conditions of the site area.
- Geotechnical investigation and evaluation of foundation parameters
- River, lake, other water bodies, water retaining structures, etc.
- Nearest military and civilian airports.
- Meteorological and environmental data which affect plant design and gaseous radioactive effluents, viz., wind speed, direction and duration (wind roses), data for design basis wind loads, precipitation, peculiarities of local meteorological conditions including effect of terrain, which could have impact on diffusion of radioactive releases.
- Population distribution (sector wise) in specified zone (currently 16 km) around the plant, available shelter facilities.
- Nature of land use and produce.
- Water utilisation and irrigation.
- Flood
- Shore line erosion
- Waste management; overall philosophy covering solid waste management, effluent treatment and water utilisation.
- External man induced events.

(3) Building, Structures and Equipment

- Layout of plant bringing out location of all buildings and structures and general description of the layout requirements and functional requirements of all buildings and structures important to safety should be provided.
- Layout of equipment of safety systems and safety related systems should include, amongst other aspects, that

requirements of ISI, nuclear security, operational surveillance, fire safety, radiation zoning, internal events, maintainability and life extensions have been addressed.

- Description of each of the buildings and structures important to safety should cover the following:
 - (i) Functional and safety requirements.
It should include shielding aspects for bulk shielding and penetrations through shielding.
 - (ii) Design basis and design requirements to satisfy functional and safety requirements.
 - (iii) Design requirements pertaining to geotechnical aspects and foundation design.
 - (iv) Layout and considerations for layout.
It should include layout of bulk shielding structures, penetrations through shielding structures and areas/rooms containing radioactive systems/components/equipment.
 - (v) Analysis methodology, mathematical modeling, codes, guides and standards used for analysis/design, design for strength, serviceability and shielding requirements, seismic design, description of loads, design values of loads and load combinations, materials and material properties, important assumptions in analysis and design.
 - (vi) Construction and maintenance aspects, provision for in-service inspection.
 - (vii) Special requirements such as tests, structural instrumentation, fire protection, decommissioning, as applicable.
- Description of reactor building (RB) should cover containment structures, internal structure, calandria vault, vent shafts and distribution headers and air lock barrels. The following aspects should also be covered.
 - (i) Containment pressure, leak tightness, containment penetrations, provisions for meeting leak tightness requirements, provision for conducting proof test and leakage rate tests including instrumentation for structural monitoring and leakage rate tests.

(ii) Containment pressure suppression system, separation of high enthalpy volume to low enthalpy volume, vent system and suppression pool, provisions for pressure equalisation within RB, operational aspects of airlocks and interlock logics.

- Service building description should cover radiation zoning aspects and shielding aspects for rooms/areas handling radioactive jobs.
- Spent fuel storage building description should cover fuel transfer duct, spent fuel pool and spent fuel bay, test requirements of the pool and bay and shielding aspects associated with these areas/structures.

(4) Reactor, Steam Generator and Auxiliaries

- Overall general description of reactor system
- Station heat balance for normal 100% FP operation.
- Reactor and its components design and construction

Design basis and description of reactor components bringing out functional requirements, codes and standards specified for design and manufacture, installation and inspection, materials and considerations for material selection, mechanical design description with major dimensions, figures, etc; design and operating conditions (pressures, temperature, etc.); considerations for design loads, allowed stresses/deflections and postulated emergency/fault conditions considered. Details of some of the information may be covered by references to appropriate documents, design basis reports and design manuals. In this section the following should be covered.

- (i) Calandria and end shields
- (ii) Coolant channel assemblies covering coolant tubes, calandria tubes, end fitting assemblies and associated components. Aspects regarding deterioration of material properties of coolant tubes during service life, and remedial measures and ISI aspects are to be brought out.
- (iii) Feeders and headers; their insulation cabinets.
- (iv) Adjuster rod system including its shielding and cooling aspects
- (v) Primary and secondary shutdown systems: Systems and component descriptions, and operational aspects, actuation timings and shielding requirements.

(a) Heat Transport System

System description and evaluation should show that the heat transport system is adequate to accomplish its intended objective and to maintain its integrity under normal operation and anticipated operational occurrences. Where relevant, the selection of specific values or ranges of values for various parameters should be explained from the stand point of safety.

Following should be covered.

(i) Design Bases

- à Principal features and performance objectives of the system and its components.
- à Key design parameters for the system and its components including pressures, temperatures, flows (design values as well as various set points), volumes, channel flow distribution and its compatibility with channel power distribution (as determined by reactor physics design).
- à Design cyclic loads expected during service life time, their estimated frequency including considerations of startup and shutdown operation, power level changes, emergency and recovery conditions, switching operations and hydrostatic tests.
- à Considerations regarding material selection.
- à Postulated initiating events considered for design of the system and its components, including application of single failure criterion/redundancy.
- à System operability/status under Class IV power failure, instrument air failure, etc.
- à The code and classification applied in design, construction, inspection and testing of the system and its components.

(ii) System Design Description

Descriptions and assessments to be given for the system and its components along with figures as required (including flow sheets, cross-section views, sketches etc.) bringing out how the various safety related design basis and performance objectives are met. The coverage should include:

- à Overall system description along with schematic flow

sheet indicating key process parameters for normal full power conditions.

- à Description of individual sub-systems and components of main system mainly steam generator, primary coolant pumps (including data related to flow coast down) pressuriser and pressure control (give adequacy with respect to postulated shrinkage/swell rates) over pressure relief (give adequacy with respect to postulated transient, grid disturbance).
 - à Description of other associated systems of PHTS viz. supply to fuel handling system, and shutdown cooling system.
 - à Description of high pressure auxiliaries of PHT system, viz. bleed condenser and PHTS purification filters.
 - à Description of low pressure auxiliaries of PHT system, viz. heavy water storage and cover gas, purification system, service systems, de-gassing and leakage collection system.
 - à Description of emergency core cooling system including high pressure accumulator, low pressure re-circulation circuit, injection types, operation logics.
 - à Description of small leak handling system.
 - à Description of SG secondary side systems covering SG assemblies, SG feed water system, auxiliary feed water system; provisions for back up water supply to SG under emergency conditions.
 - à System operational aspects including heat up, cooldown and associated D₂O swell and shrinkages.
- (b) Moderator System
- (i) System functional requirements, design bases and design parameters, design and seismic classification, material selection aspects.
 - (ii) Description of main moderator circulation system; its operational aspects covering normal operation, anticipated operational occurrences considered in design.
 - (iii) Moderator auxiliary system including cooling system for regulating and shim rods, cover gas system, purification system, leakage collection, evaporation and

clean-up, sampling, leakage collection, addition and transfer and resin deuteration system.

- (iv) Liquid poison addition/injection system to moderator. (Highlight provisions to ensure that required quantity of poison is maintained in moderator).

(c) Reactor Auxiliary Systems

For each system, give system functional requirements, design bases and considerations and system description highlighting the safety aspects and flow sheet.

- (i) Calandria vault cooling system
- (ii) FM vault and pump room atmosphere cooling system
- (iii) End shield cooling system
- (iv) Heavy water vapour recovery system
- (v) Vapour suppression system
- (vi) Spent fuel storage bay cooling and purification system
- (vii) Annulus gas system.

(5) Fuel and Fuel Handling

- Fuel-design objectives/functional requirements; design description and salient design data; environmental conditions for fuel during normal operation; mechanical strength and thermal design aspects; bundle power envelopes. Aspects relating to fretting, wear, etc. Fuel failure causes and preventive provisions.
- Fuel changing requirements, bases and ground rules.

(a) D₂O Supply System

Design description ON and OFF reactor requirements, emergency supply, FT supply system

(b) Fuelling Machines

- (i) Head, bridge and carriage (D₂O hydraulics, oil hydraulics, electrical controls and computer control); inherent safety features for control system, various ram forces and measures to safe guard bundles from excessive loads, operational aspects (including normal refuelling sequences and anticipated operational occurrences, design provisions in FM with respect to PHTS integrity, FM pressure control system.

- (ii) Fuel transfer system and its components both inside and outside the reactor building; controls (D₂O hydraulics, oil hydraulics electrical controls and computer control) and operational aspects.
- (iii) Inspection facilities for suspected fuel storage facility for defective fuel bundles
- (iv) Description of
 - Fuel storage facility including overhead crane
 - System component classification
 - In-service inspection, maintenance and calibration aspects of FM and fuel transfer equipment.

(6) TG & Electrical Output System

Safety aspects of turbine cycle and turbine generator related equipment including protection and control features may be given. Following should be covered.

- Main steam system and secondary cycle including steam mains, condensing system, condensate and feed water systems, and steam dump, discharge and relief systems.
- Steam turbine, its CIES and governor valve systems, governing and protective systems; permissible frequency ranges for turbine operation; turbine missile prevention.
- Turbine lubrication systems and bearings.
- Generator and auxiliaries including hydrogen cooling, seal oil systems, static excitation systems and protection.
- Turbine generator control and protection including list of trips and annunciations.

(7) Control & Instrumentation

The description should bring out design criteria/bases and functional requirements and how these are met in the detailed design of C&I systems. These should include for example redundancy, reliability, diversity, separation among protective channels, separation between protection and regulating function, testability and calibration, etc.

Following topics should be addressed

- Design criteria and design bases for C&I systems
- Special requirements for instruments of safety systems and safety related systems.

- Control centre and their equipment covering the main control room and supplementary control centre. Computer systems used for control or protection, provisions for protection against faults in hardware/software.
- Operator information systems and operator aids.
- An instrumentation plan
- Overall plant control and control programs.
- Reactor regulation/reactivity control; control aspects of various reactivity devices, flux tilt control/zone control.
- Reactor protective/shutdown systems (C & I aspects): Design objectives, system description covering sensors, trip logics and instrumentation, PSS(SDS1), SSS(SDS2) and moderator liquid poison addition systems.
- Devices for measuring reactor power and their calibrations.
- Startup instruments.
- Instrumentation for process systems covering monitoring, controls and protective actions for various parameters of moderator and PHT systems; PHT pressure control including IRVs, SG pressure control, SG level control, turbine generator control, deaerator level control, bleed condenser pressure and level control, etc.
- Heavy water leak detection system,
- Radiation monitoring systems (area monitors, contamination monitors, personnel and environmental monitors).
- Instrumentation for engineered safety features/accident mitigation systems.
- Instrumentation for ECCS, small leak handling.
- Failed fuel detection systems.
- Instrumentation for containment including instrumentation for accident conditions.
- Control power supplies and distribution.
- Instrument air.

(8) Plant Services

- Process water system (active and non-active): Highlight safety related functional requirements, design considerations and design bases, heat loads, design parameters, design descriptions, provisions for abnormal conditions considered in design.

- Fire fighting water system : functional requirements including flow requirements, its usage for functions other than fire fighting (e.g. emergency water source to reactor systems); safety and seismic classifications of various parts of the systems. The description should include water sources, prime movers (diesel and electrical drive) and provisions for isolation between parts of systems having different safety/seismic classifications.
- Ultimate heat sink for emergency conditions: heat load required to be catered, storage capacity, make-up sources and provisions on long term basis.
- Condenser cooling water systems and domestic water systems
- Drainage system: Highlight the active drainage and its disposal; performance of the systems during off-normal situation.
- Ventilation systems for primary and secondary containment-functional requirements/design basis and systems description, including key parameters.
- Containment related engineered safety features (containment isolation systems, PC filtration and pump back system, primary containment controlled discharge system, secondary containment re-circulation purge system. Functional requirements/design basis and systems description including key parameters).
- Ventilation system for service building and turbine building; control room ventilation including emergency ventilation for control room habitability.
- Station service electrical system

Design objectives, bases and description of salient features of station service electrical system, covering:

- Off-site source for station service electric supply.
- On-site emergency power systems (Class III, II, I); loads for each of the DGs, batteries, UPS etc., EMTR and load shedding schemes, cables and cabling. Description should bring out redundancy, separation of redundant supplies, buses and cable routes.
- Other safety related aspects, e.g. emergency lighting, systems grounding, lightning protection, etc.

- Compressed Air Systems (instrument air, service air, mask air)
 - (i) Functional requirements/design basis and systems description including key parameters; operational aspects; off-normal conditions considered in design.
- Fire Protection Systems
 - (i) Design approach followed in fire protection.
 - (ii) Fire hazards identified
 - (iii) Fire fighting provisions: design codes and standards followed.
 - (iv) Fire alarm system functional requirements and description.
- Communication systems-within plant and with outside agencies.

(9) Radiation Hazards Control and Radioactive Waste Management

9(a) Radiation Hazards Control

This chapter should cover provisions to control radiation exposure of plant personnel and members of public resulting from plant operation with following topics addressed.

- Provisions for exclusion zone, sterilized zone, etc.
- Design/expected radiation levels in various plant areas.
- Access control- functional requirements and provisions including door interlock system.
- Contamination control- zoning system (philosophy and details; control of personnel movement; operating island).
- Radiation monitoring and alarms- functional requirements and details of monitors, their types, ranges and locations.
- Provisions for off-site check of contamination- ESL and its objectives.
- Emergency Planning- Philosophy and overview covering various types of emergencies (give reference to the detailed emergency manual).

AERB Safety Manual, 'Radiation Protection for Nuclear Facilities, AERB/NF/SM/O-2(Rev. 4)', published in 2005 gives the detailed guidelines for radiation protection.

9(b) Radioactive Waste Management

This chapter should cover provisions for safe handling, treatment, storage and disposal of all radioactive wastes, i.e. solid, liquid and gaseous. Following should be addressed.

- Overall philosophy of the radioactive waste management scheme.
- Solid radioactive waste.
 - (i) Functional requirements/design basis; estimate of nature, volumes and activities of solid waste to be handled; categorisation of wastes.
 - (ii) Description of the solid waste management scheme and the systems involved.
- Radioactive Liquid Wastes
 - (i) Basic requirements including allowed limits for liquid effluents and their basis.
 - (ii) Estimated liquid waste quantities to be handled, giving nature, volume and activity levels.
 - (iii) Description of handling scheme and systems involved for treatment, storage and disposal; monitoring system.
 - (iv) Provisions for handling off-normal situations, e.g. activity leaks in the process water.
- Active Gaseous Waste
 - (i) Basic requirements including limits for air borne effluents and their basis.
 - (ii) Activity release monitoring system.

(10) Reactor Physics and Shielding

10(a) Reactor Physics (Nuclear Design)

Description of reactor physics and nuclear design aspects of reactor core. This should include data on reactivity coefficients, reactivity worths of reactor control and shutdown devices and other physics data required for safety analysis for various PIEs such as loss of regulation accidents, loss of coolant accident, etc. Methods/models used for physics design analysis and assessment should also be brought out.

Following should be covered.

- Overall description of core design including fuel, D₂O, reactor control devices and shutdown systems.

- Reactor core characteristics during various phases from initial core to equilibrium conditions.
- Flux profiles and channel power distribution.
- Worth of regulating and protective devices and rates of insertion/withdrawal.
- Reactivity coefficients : fuel temperature, power, void; moderator; moderator purity effect; coolant purity effect, coolant temperature, moderator temperature effect.
- Xenon load transients for various power level changes.
- Shutdown reactivity margins under normal and accident conditions.
- Fuel management- objectives and channel selection aspects.

10(b) Shielding

- Radiation sources; design specified/expected dose rates in various areas.
- Description of shielding provision for β , γ and neutrons and other design considerations covering shielding of reactor vaults, FM service area, fuel transfer rooms, moderator room, PHT system equipment, various penetrations and any other sources of radiation in reactor building.
- Circuit activities in PHT coolant, moderator and other active circuits.
- Local shielding requirements outside reactor building including spent fuel transfer tube and their details.

(11) Shared Systems

- Identification of systems which are shared by more than one unit at the station.
- Safety implications of the sharing feature. Specifically, capability to handle accident in one unit and orderly shutdown in the other unit(s) should be brought out.

(12) Commissioning

- Scope of commissioning activities.
- Organisations involved and their responsibilities.

- Commissioning phases.
- Preparatory work involved, e.g. preparation of documents, procurement of spares, setting up of reference facilities, training.
- Commissioning work sequence, e.g. equipment testing, pre-service inspection, system transfers, pre-operational checks, logic checks, performance tests, etc.
- Commissioning program to be carried out covering major milestone starting from pre-criticality to start of commercial operation.
- Commissioning reports.

(13) Safety Management during Operation

This section should provide information on station organisation, training programs, operators qualification, operating plans, etc. to ensure adequacy of safety during plant operation.

The following information should be included in this section.

- Station organisation (This should include functional description of each group as per the organisation, such as technical group, O&M group, QA group, radiation protection supervision, etc.).
- Training (This should include curriculum, level of training, qualification method, qualification program, training centre, etc.).
- Operation during commissioning.
- Operating documents.
- Industrial Safety.
- Security Plan.
- Emergency plan.

(14) Decommissioning

This should cover

- Broad decommissioning plan
- Design provision to facilitate decommissioning

(15) QA Program

In order to provide assurance that the design, construction and operation of the proposed nuclear power plant are in conformance

with applicable regulatory requirements, it is necessary that a quality assurance (QA) program be established by the applicant.

The quality assurance program should bring out the description of the QA program, either to be established or being practiced by the applicant. This chapter should include the following:

- Organisation and responsibilities
- QA during design phase
- QA in procurement
- QA in manufacturing
- QA during site construction
- QA during commissioning
- QA during operation.

The contents of each section should bring out the basic elements of quality assurance such as:

- Areas of quality assurance, assessment and review
- Qualification and training program
- Document control
- Examination, inspection and test control (as applicable)
- Handling shipping and storage (as applicable)
- Calibration control of measuring and test equipment
- Non-conformance control
- In-service inspection (as applicable)
- QA records
- Periodic review of QA program.

(16) Nuclear Security

- Physical protection system covering access control detection, alarm and assessment; delay and physical barrier; communication; plant configuration control; response force.
- Training and licensing aspects
- Quality assurance aspects

PART-B

SAFETY ANALYSIS

The objective of the safety analysis to be included in the safety analysis report is to present the predicted response of the reactor plant to postulated initiating events (PIEs) to demonstrate with reasonable assurance that the plant has capacity for preventing accidents, or mitigating their effects sufficiently to preclude undue risk to public health and safety. It is to be demonstrated that for the PIEs considered, the radiation dose to a member of the public is not in excess of the reference emergency doses prescribed by AERB and other acceptable criteria or goals are complied with.

Objectives of analyses and acceptance criteria for specific PIEs/event sequences should be brought out.

A step-by-step sequence of events from initiating event to the final stabilised condition should be given on a time scale (important events are like reactor trip, PHT system pressure reaching safety relief valve set point, safety relief valve operation, containment isolation signal initiation, containment isolation, etc.). All required operator actions should be identified. Operator action should be credited with availability of unambiguous signal and time available for operator action. The actuation/operation of reactor protection system and engineered safety features (on auto or by operator actions) should be brought out.

Calculational models, assumptions and inputs should be brought out (either in the report or by reference). Results considered relevant and important for safety assessment should be brought out, viz., assessment of reactor shutdown, core cooling, integrity of fuel, integrity of PHT system boundary, performance of containment and other barriers, and radioactivity releases.

While the salient results are to be given in the main report, analysis details/modelling aspects may be given in a suitable number of Appendices.

The following should be covered:

- General considerations bringing out safety objectives and principles and an overview of the safety features of the plant (both inherent and engineered), which have a bearing on prevention of initiating events and their mitigation.
- Dose criteria and limits : authorised/acceptable releases for normal operation and accident conditions and their bases.
- Other acceptable criteria or goals for safety analysis.
- Safety analysis for postulated initiating events both internal and external to plant, within the design bases should be as per AERB

safety guide (AERB/SG/D-5). Typically, the following items should be covered.

- (a) Reactivity and power distribution anomalies; loss of regulation accident.
- (b) Pipe failures in PHT System (LOCA)
 - à Assessment of a range of break sizes and locations, upto and including double ended break in the largest pipe in the system.
 - à SG tube break
 - à Pressure tube failures with and without accompanying failure of corresponding calandria tube.
- (c) Failure in secondary steam line.
- (d) Main steam line break with SG tube failure
- (e) Loss of feed water
- (f) Failures in PHT System other than LOCA.
 - à Failure of PHT Circulation
 - à Channel flow blockage
 - à Failures in PHT pressurization system.
 - à Failure in PHT pressure relief system
 - à Failure in shutdown cooling system
 - à Shaft seizure of one PHT pump
- (g) Failures in moderator system, covering failures in circulation and inventory depletion.
- (h) Failures in shield cooling system (end shield cooling and calandria vault cooling), covering failures in circulation and inventory depletion.
- (i) Loss of electrical power.
 - à Class IV power failure
 - à Station blackout
- (j) Fuel handling system failures
- (k) Loss of computer control
- (l) Earthquake to a value of SSE
- (m) Design basis flood
- (n) Turbine failure leading to missile being thrown off
- (o) Multiple failure involving LOCA with impairment in availability of ECCS

- (p) LOCA with impairment in containment function (including containment isolation failure)
- (q) LOCA with impairment of SG crash cooling
- (r) Fuel handling accident coincident with impairments in containment functions.
- (s) Identification of vital/inner areas based on design basis threats and outcome of safety analysis.
- (t) Analysis of physical protection system and computation of risk

The deterministic (accident) analysis should also be performed for some beyond design events involving multiple failures including operator error, to provide an aid to emergency planning and insight to ultimate plant capability, any cliff-edge effect and consideration of the feasibility of incorporating new engineered safety feature for safety enhancement.

It is desirable to perform all three levels of PSA for nuclear reactors. As a minimum requirement, plant should carry out level-1 PSA with internal and external events, as applicable to the plant. Shutdown and low power PSA should also be performed to have risk insights from these plant states.

The safety analysis should establish the conditions and limitations for safe operation. This would include items such as:

- Safety limits for reactor protection and control and other engineered safety systems.
- Operational limits and reference settings for the control system.
- Procedural constraints for operational control of processes.
- Identification of the allowable operating configuration.

Presentation of results of safety analyses carried out by both deterministic and probabilistic approaches, should be comprehensive so as to facilitate proper understanding, review and assessment. The guidelines on format and contents of these analysis reports are given in Annexures 3 and 4.

APPENDIX-3

(Refer Section 3.3)

GUIDELINES FOR CONTENTS OF SAFETY ANALYSIS REPORTS FOR RESEARCH REACTOR

1. INTRODUCTION

1.1 General

This document gives guidelines for the organisation and contents of safety analysis reports for research, experimental and test reactors.

1.2 Format of Safety Analysis Reports

- (i) A table of contents should be provided. When a report consists of several volumes, at least an abridged table of contents should be included in each volume.
- (ii) All information presented in drawings, maps, diagrams, sketches and charts should be legible, the symbols used should be defined.
- (iii) Abbreviations used should be consistent with their general usage and those not in general usage should be defined in each volume where they are used.
- (iv) Each safety analysis report should consist of sections, each section covering a particular system or topic. The discussion within a section should be reasonably complete and each section should be a self-contained part of the report. Tables and figures (including flow-sheets as applicable) should be included as required. Where necessary, cross references should be given.
- (v) Removal and reinsertion of a page or pages and insertion of a modified page or pages should be easy.

1.3 Issue of Safety Analysis Reports

Safety analysis reports should be issued in two successive stages as indicated below:

- (a) Safety Analysis Report (Preliminary) : This should comprise a preliminary description of the facility and safety analysis based on the intended siting and design. Where any of the topics cannot be given full coverage at this stage, sufficiently detailed information (design bases, specifications, calculations) should be provided to assess the feasibility of the plant at the proposed site, with regard to public health and environmental safety. This should be submitted for approval before commencement of construction.

- (b) Safety Analysis Report (Final) : This should be the updated version of the safety analysis report (preliminary) with current and more specific information. It should also include detailed description of the operational aspects and safety of operating personnel.

1.4 Remarks

If items not discussed or included in any of the suggested sections are relevant to the safety of the plant, these should be included by insertion of additional sections or sub-sections. Similarly, if some of the sections are not relevant to the safety of the plant, these may be omitted. Ritualistic adherence to the suggested format and coverage should not substitute for systematic and logical presentation of information, associated with the evaluation of individual safety aspects peculiar to the particular plant.

1.5 Definitions

- (i) Principal Design Criteria : These are the fundamental architectural and engineering design objectives established for the project, and represent the broad frame of reference within which the more detailed plant design effort is to proceed, and against which the project will be reviewed.
- (ii) Design Bases : That information which identifies the specific functions to be performed by a major component or system in terms of performance objectives, together with specific values or range of values chosen for controlling parameters as reference bounds or limits for design.
- (iii) Design Evaluation : A study of the functional and physical features of the major plant systems and components to determine:
 - (a) whether the design can or has met performance objectives with an adequate margin of safety,
 - (b) the identity and susceptibility of failures, either in equipment or control over process variables, which could be possible initiating events for accidents.
- (iv) Safety Analysis : A study of the predicted response of the reactor plant to postulated initiating events to determine with reasonable assurance whether the plant has capacity for preventing accidents or mitigating their effects sufficiently, to preclude undue risk to public health and safety.

2. CONTENTS OF SAFETY ANALYSIS REPORT

Safety analysis reports should be precise, lucid, clear and easily understandable. These should contain sufficient information to enable AERB

to conduct a review of the safety analysis. Where necessary, further details on certain information can be given by reference to specific documents.

In terms of nature of content, there are two parts of the safety analysis report as follows:

Part-A : Design description, bringing out the design bases, safety aspects of the plant and data relevant for safety analysis.

Part-B: Safety analysis, giving an assessment of the consequences of postulated initiating events (PIEs) and event sequences.

PART-A

(1) General Description of Plant

- Overall plant summary description covering plant layout, reactor systems and auxiliaries and safety systems.

(2) Safety Objectives and Classification

- Overall safety philosophy
- Safety, seismic and quality classification of components, systems and structures; their bases and categories; tabulations giving detailed classification list.
- Overview of quality assurance in design, manufacture, construction, commissioning, operation and decommissioning.

(3) Siting and Environmental Data

This section should cover site characteristics that have influence on the design and operating plans of the research reactor. Data which have formed inputs for design basis parameters, e.g. seismic, wind loads, flood levels, meteorological, geological and hydrological characteristics, population distribution and land use should be included.

The extent of the evaluation and the amount and detail of information provided on any particular factor should be commensurate with the importance of that factor to safety of the proposed facility.

Following may be covered.

- Site location : Geographical location indicating longitude, latitude, distance/direction with respect to major towns/landmarks, location map and access roads/routes covering at least 50 km from the facility.

- Geological setting and tectonic set up; effect on design of foundation and structures.
- Earthquake design basis and parameters covering the database used, regional geology and tectonic, earthquake occurrence history. Applicable attenuation law for peak ground acceleration (PGA). PGAs for S1 (OBE) and S2 (SSE) levels, PGA response spectra, spectral compatible accelerograms.
- Topography and ground-water conditions of the site area.
- Geotechnical investigation and evaluation of foundation parameters
- Rivers, lakes, other water bodies and water retaining structures.
- Military and civilian airports
- Meteorological and environmental data which affect plant design and gaseous radioactive effluents, viz. wind speed, direction and duration(wind roses), data for design basis wind loads, precipitation, peculiarities of local meteorological conditions including effect of terrain which could have impact on diffusion of radioactive releases.
- Population distribution in exclusion and sterilization zones as applicable, depending on the type and power of the RRs; available shelter facilities.
- Nature of land use and produce.
- Water utilisation and irrigation.
- Waste management overall philosophy covering solid waste management, effluent treatment and water utilisation.
- External man induced events.

(4) Building, Structures and Equipment

- Layout of plant bringing out location of all buildings and structures and general description of the layout requirements and functional requirements of all buildings and structures important to safety, should be provided.
- Layout of equipment of safety systems and safety related systems should include, amongst other aspects, that requirements of ISI, nuclear security, operational surveillance, fire safety, radiation zoning, internal events, maintainability and life extensions have been addressed.
- Description of each of the buildings and structures important to safety should cover the following:

- (i) Functional and safety requirements.
 - (ii) Design basis and design requirements to satisfy functional and safety requirements.
 - (iii) Design requirements pertaining to geotechnical aspects and foundation design.
 - (iv) Layout and considerations for layout.
 - (v) Analysis methodology, mathematical modelling, codes, guides and standards used for analysis/design, design for strength, serviceability and shielding requirements, seismic design, description of loads, design values of loads and load combinations, materials and material properties, important assumptions in analysis and design.
 - (vi) Construction and maintenance aspects, provision for in-service inspection.
 - (vii) Special requirements such as tests, structural instrumentation, fire protection and decommissioning, as applicable.
- Description of Reactor Building (RB) should cover confinement/containment structures, internal structure, calandria vault, vent shafts and distribution headers and air lock barrels as applicable, based on graded approach commensurate with reactor power level and complexity. The following aspects should also be covered.
 - (i) Containment pressure, leak tightness, containment penetrations, provisions for meeting leak tightness requirements, provision for conducting proof test and leakage rate tests, including instrumentation for structural monitoring and leakage rate tests.
 - (ii) Mechanism for containment pressure reduction on a DBA, if applicable, for high power reactors.
 - Service building description should cover radiation zoning aspects.
 - Spent fuel storage building description should cover fuel transfer duct, spent fuel pool and spent fuel bay and test requirements of the pool and bay.

(5) Reactor

- Overall general description of reactor system

- Heat balance for normal 100% FP operation.
- Reactor and its components design and construction

Design basis and description of reactor components bringing out functional requirement, codes and standards specified for design and manufacture, installation and inspection, materials and considerations for material selection, mechanical design description with major dimensions, figures etc; design and operating conditions (pressures, temperature, etc.); considerations for design loads, allowed stresses/deflections, postulated emergency/fault conditions considered. Details of some of the information may be covered by references to appropriate documents, design basis reports and design manuals. Aspect of ISI should also be covered. In this section the following should be covered.

- (i) Pile block
- (ii) Reactor vault and shield
- (iii) Provisions for neutron beams and other horizontal and vertical provisions for experimental/irradiation facilities.
- (iv) Reactivity control provisions
- (v) Primary and secondary shutdown systems : Their systems and components description and operational aspects, actuation timings and shielding requirements.

- Reactor Coolant and Associated Systems

System description and evaluation should show that the reactor coolant systems are adequate to accomplish its intended objective and to maintain its integrity under normal operation and anticipated operational occurrences. Where relevant, the selection of specific values or ranges of values for various parameters should be explained from the stand point of safety.

Following should be covered.

- (i) Design Bases
 - à Principal features and performance objectives of the systems and their components.
 - à Key design parameters for each system and its components including pressures, temperatures, flows (design values as well as various set points), volumes, flow distribution and its compatibility with

power distribution (as determined by reactor physics design).

- à Design cyclic loads expected during service life time, their estimated frequency including considerations of startup and shutdown operation, power level changes, hydrostatic tests and emergency operations, if any.
- à Considerations regarding material selection.
- à Postulated initiating events considered for design of each system and its components, including application of single failure criterion/redundancy.
- à System operability/status under Class IV power failure, instrument air failure, etc.
- à The code and classification applied in design, construction, inspection and testing of the system and its components.

(ii) System Design Description

Descriptions and assessments to be given for each system and its components, along with figures as required (including flow sheets, cross-section views, sketches, etc.) bringing out how the various safety related design bases and performance objectives are met. The coverage should include:

- à Overall system description along with schematic flow sheet indicating key process parameters for normal full power conditions.
- à Description of individual sub-systems and components of main systems, and mainly coolant pumps (including data related to flow coast down) pressure profile and inter connections between sub-systems.
- à Description of shutdown cooling system.
- à Description of auxiliaries, viz. storage tanks, if any, and cover gas, purification system, service systems, de-gassing and leakage collection system, as applicable.
- à Description of emergency core cooling system including low pressure re-circulation circuit, injection types, operational logic, as applicable.
- à System operational aspects.

- Moderator System, if independent of coolant system
 - (i) System functional requirements, design bases and design parameters, design and seismic classification, material selection aspects.
 - (ii) Description of main moderator circulation system; its operational aspects covering normal operation and anticipated operational occurrences considered in design.
 - (iii) Moderator auxiliary system including cooling system, cover gas system, purification system, leakage collection, evaporation and clean-up, sampling, addition and transfer, etc.
- Reactor Auxiliary Systems

System functional requirements, design bases considerations and system description, highlighting the safety aspects and flow sheet should be included for all systems, as applicable.

 - (i) Vault and shield cooling system, as applicable.
 - (ii) Spent fuel storage facility, cooling and purification system.
- Engineered Safety Features

Brief description highlighting features of engineered safety features incorporated in the reactor should be included. These features may vary from reactor to reactor and should cover emergency core cooling provisions, provisions to prevent release of unacceptable amount of radioactivity to atmosphere and other features to mitigate consequences of DBAs.

(6) Fuel and Fuel Handling

- Fuel-design objectives/functional requirements; design description and salient design data; environmental conditions for fuel during normal operation; mechanical strength and thermal design aspects; bundle power envelopes. Aspects relating to fretting, wear, etc. Fuel failure causes and preventive provisions.
- Fuel changing requirements, bases and ground rules.
- Fuel handling and transfer facilities

Design description of facilities for safe handling of fuel during refuelling operations and storage. This should include provision of assured cooling to irradiated fuel during refuelling, shielding provisions and provisions for handling anticipated occurrences during refuelling.

- (i) Inspection facilities for suspected fuel, storage facility for defective fuel bundles
- (ii) Description of
 - Fuel storage facility including overhead crane
 - System component classification
 - In-service inspection, maintenance and calibration aspects of fuel handling and transfer facilities.

(7) Control and Instrumentation

The description should bring out design criteria/bases and functional requirements and how these are met in the detailed design of C & I systems. These should for example include e.g. redundancy, reliability, diversity, separation between protection and regulating function, separation of redundant channels of protection system, testability and calibration, etc.

Following topics should be addressed

- Design criteria and design bases for C&I Systems
- Special requirements for instruments of safety systems and safety related systems.
- Control centre and their equipment covering the main control room and supplementary control centre. Computer systems used for control or protection, provisions for protection against faults in hardware/software.
- Operator information systems and operator aids.
- Overall plant control and control programs.
- Reactor regulation/reactivity control; control aspects of various reactivity devices, and where applicable, flux tilt control/zone control.
- Reactor protective/shutdown systems (C&I aspects) : design objectives, system description covering sensors, trip logic and instrumentation
- Devices for measuring reactor power and their calibration.
- Startup instruments.
- Instrumentation for process systems covering monitoring, controls and protective action for various parameters including primary coolant activity monitoring.
- Radiation monitoring systems (area monitors, contamination monitors, personnel and environmental monitors).

- Instrumentation for engineered safety features/accident mitigation systems.
- Instrumentation for ECCS
- Failed fuel detection systems.
- Instrumentation for containment including instrumentation for accident conditions.
- Control power supplies and distribution.
- Instrument air.

(8) Plant Services

- Ventilation systems
 - (i) Ventilation systems- functional requirements/design basis and systems description including key parameters.
 - (ii) Containment related engineered safety features (containment isolation systems, functional requirements/design basis and systems description including key parameters).
 - (iii) Ventilation system for service building; control room ventilation including emergency provisions, if any, for control room habitability.
- Electrical system

Design objectives, bases and description of salient features of electrical system, covering:

 - (i) Off-site source for station service electric supply.
 - (ii) On-site emergency power systems (Class III, II, I); loads for each of the DGs, batteries, UPS etc., EMTR and load shedding schemes, cables and cabling. Description should bring out redundancy, separation of redundant supplies, buses and cable routes.
 - (iii) Other safety related aspects e.g. emergency lighting, systems grounding, lightning protection etc.
- Compressed air systems (instrument air, service air, mask air)
 - (i) Functional requirements/design basis systems description including key parameters, operational aspects; off-normal conditions considered in design.

- Fire protection systems
 - (i) Design approach followed in fire protection.
 - (ii) Fire hazards identified
 - (iii) Fire fighting provisions; design codes and standards followed.
 - (iv) Fire alarm system, functional requirements and description.
- Ultimate heat sink for emergency conditions : Heat load required to be catered, storage capacity, make-up sources and provisions on long term basis.
- Communication systems : Within plant and with outside agencies.

(9) Utilisation

This section should cover

- Scope of utilisation of the reactor, e.g. research, isotope production, material testing, training of manpower, etc.
- Facilities provided/to be provided for utilisation of the reactor, e.g. description of the neutron beam tubes, horizontal and vertical facilities inside and outside the core for basic and applied research, material testing, neutron radiography, in-pile test loops, isotope production and handling facilities, etc.
- Reactor systems being shared with research and experimental facilities.
- Highlights of research/experimental facilities which may have safety implication on the reactor and/or reactor containment.
- Highlights of facilities using special fluids and facilities with devices operating at high/low temperature or/and high/low pressure conditions.

(10) Radiation Hazards Control and Radioactive Waste Management

10(a) Radiation Hazards Control

This chapter should cover provisions to control radiation exposure of plant personnel and members of public resulting from plant operation with following topics addressed.

- Provisions for exclusion zone, sterilized zone, etc. where applicable.

- Design/expected radiation levels in various plant areas.
- Access control: functional requirements and provisions including door interlock system.
- Contamination control: zoning System (philosophy and details; control of personnel movement; operating island).
- Radiation monitoring and alarms: functional requirements and details of monitors, their types, ranges and locations.
- Provisions for off-site check of contamination: ESL and its objectives if relevant.
- Emergency Planning: Philosophy and overview covering various types of emergencies (give reference to the detailed emergency manual).

AERB safety manual on “Radiation Protection for Nuclear Facilities (Rev. 4)” published in 2005 gives the detailed guidelines for Radiation Protection.

10(b) Radioactive Waste Management

This chapter should cover provisions for safe handling treatment, storage and disposal of all radioactive wastes, i.e. solid, liquid and gaseous. Following should be addressed.

- Overall philosophy of the radioactive waste management scheme.
- Solid radioactive waste.
 - (i) Functional requirements/design basis; estimate of nature, volumes and activities of solid waste to be handled; categorisation of wastes.
 - (ii) Description of the solid waste management scheme and the systems involved.
- Radioactive Liquid Wastes
 - (i) Basic requirements including allowed limits for liquid effluents and their basis.
 - (ii) Estimated liquid waste quantities to be handled giving nature, volume and activity levels.
 - (iii) Description of handling scheme and systems involved for treatment, storage and disposal; monitoring system.

- (iv) Provisions for handling off-normal situation, e.g. activity leaks in the process water.
- Active Gaseous Waste
 - (i) Basic requirements including limits for air borne effluents and their basis.
 - (ii) Activity release monitoring system.

(11) Reactor Physics (Nuclear Design) and Shielding

11(a) Reactor Physics (Nuclear Design)

Description of reactor physics and nuclear design aspects of reactor core. This should include data on reactivity coefficients, reactivity worths of reactor control and shutdown devices and other physics data required for safety analysis for various PIEs such as loss of regulation accidents, loss of coolant accidents etc. Methods/models used for physics design, analysis and assessment should also be brought out.

Following should be covered:

- Overall description of core design including fuel, moderator, coolant, reflector, reactor control devices and shutdown systems.
- Reactor core characteristics during various phases from initial core to equilibrium conditions.
- Reactivity of experimental and irradiation facilities provided for.
- Flux profiles and power distribution. This should take in to consideration the effects of experimental/ irradiation facilities located in the core.
- Worths of regulating and protective devices and rates of insertions/withdrawal and influence of experimental facilities on them.
- Reactivity coefficients : fuel temperature, power, void, moderator; moderator purity effect, coolant purity effect, moderator temperature and coolant temperature effect..
- Xenon load transients for various power level changes.
- Shutdown reactivity margins under normal and accident conditions
- Fuel management - objectives and refuelling aspects.
- Provisions for catering to experiment and irradiation requirements.

(11B) **Shielding**

- Radiation sources; design specified/expected dose rates in various areas.
- Description of shielding provision for α , β and neutrons and other design considerations, covering shielding of pile block, areas housing primary coolant, moderator and cover gas system equipment, fuel handling and storage areas and other sources of radiation in the reactor building and other buildings.
- Circuit activities in coolant, moderator, cover gas and other active circuits.
- Local shielding requirements outside reactor building including spent fuel handling and storage areas.
- Shielding provisions for irradiation/experimental facilities.

(12) **Shared Systems**

- Identification of systems which are shared by more than one facility at a location.
- Safety implications of the sharing feature. Specifically, capability to handle accident in one facility and orderly shutdown in the other facilities, if required, should be brought out.

(13) **Commissioning**

- Scope of commissioning activities.
- Organisations involved and their responsibilities.
- Commissioning phases.
- Preparatory work involved, e.g. preparation of documents, procurement of spares, setting up of reference facilities, training.
- Commissioning work sequence, e.g. equipment testing, pre-service inspection, system transfers, pre-operational checks, logic checks, performance tests etc.
- Commissioning program to be carried out covering major milestones starting from pre-criticality to start of commercial operation.
- Commissioning reports.

(14) **Safety Management During Operation**

This section should provide information on plant organisation, training

programs, operator qualification, operating plans, etc. to ensure adequacy of safety during plant operation.

The following information should be included in this section.

- Plant organisation (This should include functional description of each group as per the organisation such as technical group, O&M group, QA group, reactor physics, radiation protection supervision, etc.).
- Training (This should include curriculum, level of training, qualification method, qualification program, training centre, etc.)
- Operation during commissioning.
- Operating documents
- Industrial Safety
- Security Plan
- Emergency Plan.

(15) Decommissioning

This should cover

- Broad decommissioning plan
- Design provision to facilitate decommissioning

(16) QA Program

In order to provide assurance that the design, construction and operation of the proposed nuclear reactor are in conformance with applicable regulatory requirements, it is necessary that a quality assurance (QA) program be established by the applicant.

The quality assurance program should bring out the description of the QA program, either to be established or being practiced by the applicant. This chapter should include the following:

- Organisation and responsibilities
- QA during design phase
- QA in procurement
- QA in manufacturing
- QA during site construction
- QA during commissioning
- QA during operation.

The contents of each section should bring out the basic elements of

quality assurance such as:

- Areas of quality assurance, assessment and review
- Qualification and training program
- Document control
- Examination, inspection and test control (as applicable)
- Handling, shipping and storage (as applicable)
- Calibration, control of measuring and test equipment
- Non-conformance control
- In-service inspection (as applicable)
- QA records
- Periodic review of QA program.

(17) Nuclear Security

- Physical protection system covering access control : detection, alarm and assessment : delay and physical barrier : communication, plant configuration control, response force.
- Training and licensing aspects
- Quality assurance aspects

PART-B

SAFETY ANALYSIS

The objective of the safety analysis to be given in the safety analysis report, is to present the predicted response of the reactor plant to postulated initiating events (PIEs) to demonstrate with reasonable assurance that the plant has capacity for preventing accidents, or mitigating their effects sufficiently to preclude undue risk to public health and safety. It is to be demonstrated that for the PIEs considered, the radiation dose to a member of the public is not in excess of the reference emergency doses established by AERB.

Objectives of analyses and acceptance criteria for specific PIEs/event sequences should be brought out.

A step-by-step sequence of events from initiating event to the final stabilised condition should be given on a time scale; Important events like reactor trip, primary coolant system pressure reaching safety relief valve set point, safety relief valve operation, containment isolation signal initiation, containment isolation, etc. All required operator actions should be identified. Operator action should be credited with availability of unambiguous signal and time available for operator action. The actuation/operation of reactor protection

system and engineered safety features (on auto or by operator action) should be brought out.

Effect and consequences on experimental facilities of any reactor system PIE and vice-versa, should be brought out.

Calculational models, assumptions, inputs should be brought out (either in the report or by reference). Results considered relevant and important for safety assessment should be brought out, viz. assessment of reactor shutdown, core cooling, integrity of fuel, integrity of primary coolant system boundary, performance of containment and other barriers, and radioactivity releases.

While the salient results are to be given in the main report, analysis details/modelling aspects may be given in suitable number of Appendices.

The following should be covered:

- General considerations bringing out safety objectives and principles and an overview of the safety features of the plant (both inherent and engineered) which have a bearing on prevention of initiating events and their mitigation.
- Dose criteria and limits : authorised/acceptable releases for normal operation and accident conditions and their bases.
- Other acceptable criteria or goals for safety analysis.
- Safety analysis for postulated initiating events. Typically, following items should be covered
 - (a) Reactivity and power distribution anomalies; loss of regulation accident.
 - (b) Pipe failures in primary coolant system (LOCA)
 - à Assessment of a range of break sizes and locations up to and including double ended break in the largest pipe in the system.
 - à Heat exchanger tube failures.
 - (c) Failure of coolant circulation through the core or where applicable through coolant channels
 - (d) Failure of shutdown cooling system
 - (e) Failures in moderator system covering failures in circulation and inventory depletion.
 - (f) Failures in shield cooling system (end shield cooling and calandria vault cooling) covering failures in circulation and

inventory depletion.

- (g) Loss of electrical power.
 - à Class IV power failure
 - à Blackout
- (h) Fuel handling system failures
- (i) Loss of computer control
- (j) Earthquake to a value of SSE
- (k) Design basis flood
- (l) PIEs together with impairment in mitigating features as considered credible
- (m) Identification of vital/inner areas based on design basis threats and outcome of safety analysis.
- (n) Analysis of physical protection system and computation of risk

The deterministic (accident) analysis should also be performed for some beyond design events involving multiple failures including operator error, to provide an aid to emergency planning, and insight to ultimate plant capability, any cliff-edge effect and consideration of the feasibility of incorporating new engineered safety features for safety enhancement.

It is desirable to perform all three levels of PSA for nuclear reactors. As a minimum requirement plant should carry out level-1 PSA with internal and external events, as applicable to the plant. Shutdown and low power PSA should also be performed to have risk insights from these plant states.

The safety analysis should establish the conditions and limitations for safe operation. This would include items such as:

- Safety limits for reactor protection and control and other engineered safety systems.
- Operational limits and reference settings for the control system.
- Procedural constraints for operational control of processes.
- Identification of the allowable operating configuration.

Presentation of results of safety analyses carried out from both deterministic and probabilistic approaches should be comprehensive so as to facilitate proper understanding, review and assessment. The guidelines on format and contents of these analysis reports are given in Annexures 3 and 4.

APPENDIX-4

(Refer Section 3.10 & 5.4.2)

DOCUMENTARY SUBMISSIONS IN SUPPORT OF APPLICATION FOR CONSENT FOR COMMISSIONING-TYPICAL FOR PHWR

The major interim stages for consenting for commissioning have been identified under sub-section 2.2.4 and are as follows.

Phase A:

- (i) Hot conditioning or passivation of the primary system and light water commissioning.
- (ii) Fuel loading of the reactor core, and part borated heavy water addition to storage, cooling and moderator systems for flushing in specified limited quantity during which criticality is not possible;
- (iii) Addition of heavy water to primary heat transport system; and
- (iv) Bulk addition of heavy water to moderator system with minimum specified boron level in heavy water to prevent reactor criticality.

Phase B:

- (i) Initial approach to criticality; and
- (ii) Low power reactor physics tests and experiments.

Phase C:

- (i) Initial system performance tests at low, medium and rated power levels as determined by the stable operation of the turbine; and
- (ii) System performance at rated power.

1. Phase A:

- (a) Hot conditioning of PHT system and light water commissioning

Applicant should submit report/completion status on the following.

- (1) Containment proof test and integrated leak rate test (ILRT) results* .
- (2) Overall commissioning activities chart, till the plant is declared commercial.
- (3) Status of commissioning activities as on date in the specified format as given below:

* ILRT should preferably be completed before bulk D₂O addition to moderator system.

1	2	3	4	4	5	6	7	8
S. No.	Commissioning Activity No. (as per over all commissioning schedule network)	Design Intent (Purpose of the activity)	Acceptance criteria	Status of compliance with respect to design intent certified by the designer	Reasons, if any, for not meeting the design intent	Likely date/ stage of completion	Agencies involved to solve problem to achieve design intent	Remarks

- (4) Report on availability of trained manpower at station.
- (5) Preventive maintenance program.
- (6) Adequacy of availability of spares.
- (7) Status on operating documents.
 - (a) System drawings
 - (b) Operating manuals
 - (c) Flow sheets
 - (d) System transfer documents
 - (e) Technical specifications for operation
 - (f) Maintenance manuals
 - (g) Training manual
 - (h) Commissioning procedures
 - (i) Commissioning reports
 - (j) Operating memos.
- (8) Status of submission on DBRs, DMs and safety reports
- (9) Submission of commissioning procedure for hot conditioning containing information on:
 - (a) Prerequisites : A certificate from the station that all prerequisites for various systems as given below, for starting hot condition have been carried out successfully and the results obtained meet the design intent and also the present status of various systems viz.

- (i) PHT system and auxiliaries
- (ii) Boiler steam and feed water system
- (iii) Moderator system
- (iv) Ventilation system
- (v) Suppression Pool system
- (vi) Reactor auxiliary systems such as end shield cooling system, calandria vault cooling system, annulus gas monitoring system.
- (vii) Common services (PW system, standby and fire fighting system, compressed air system, electrical system, general items)
- (viii) Technical status of core components as installed including coolant channel. Also, the actual garter spring locations just prior to filling of light water in PHTS.
- (ix) Commissioning of fire protection measures
- (b) Stepwise procedures for hot conditioning.
- (c) Observations, data collection, tests to be conducted, etc. to be highlighted.
- (10) Submission of commissioning procedure for
 - (a) PHT system commissioning with light water
 - (b) ECCS tests with light water including integrated test.
- (b) Fuel loading of reactor core, and part borated heavy water addition to storage, cooling and moderator system for flushing in specified limited quantity during which criticality is not possible.

Submissions made shall include completion certificates and current status in respect of the following:

- (1) System transfer from construction to commissioning/operation.
- (2) Light water commissioning of moderator, PHT and ECC systems.
- (3) Draining of light water and drying, purging and filling the systems with Helium.
- (4) Hot conditioning report with
 - (a) Report on actual garter spring location after draining and drying and the analysis to evaluate if the garter

spring locations need to readjusted, if the garter springs are displaced from their original position

- (b) Report on PSI/ISI of coolant channels covering parameters like straightness, bow, roughness, internal diameter, etc. at selected locations.
- (5) Pattern of fuel loading.
- (6) Vapour recovery system
- (7) Heavy water leak detection, collection, addition and transfer system including stack loss and tritium monitoring system.
- (8) Procedures for addition of limited quantity of D₂O in moderator and related auxiliary systems, including special precautions and administrative controls to ensure adequate poison concentrations in the moderator.
- (9) Establishing the operating island.
- (10) Radiological zoning system.
- (11) Commissioning of radiation monitoring system.
- (12) Commissioning of chemical, bio-assay and ESL laboratories.
- (13) Availability of adequate health physics facilities for the station start up and operations.
- (14) Status of natural and depleted uranium or thorium fuel bundles to be loaded.
- (15) Phase B commissioning arrow diagram.
- (16) Summary of commissioning tests completed and the present status of deficiencies.
- (17) Status on operation and safety documents.
- (18) Status on pending ECNs.
- (19) Procedures for initial fuel loading.
- (20) Status of fuel handling system.
- (c) Addition of heavy water to PHT system.
 - (1) Procedures for addition of D₂O in PHT system.
 - (2) Commissioning report on initial fuel loading.
 - (3) Operability of protective system including primary and secondary shutdown systems and poison addition system such as ALPAS, LPIS, etc.
 - (4) Start-up instrumentation.

- (5) Ion chambers/neutron detectors, their source checking and end connection to regulating and protection circuits.
 - (6) Status on pending items and review of earlier decisions.
 - (7) Status on establishing the reference base data for axial creep measurements with fuelling machines.
- (d) Bulk addition of heavy water to moderator system with minimum specified boron level in heavy water to prevent reactor criticality

Applicant should submit report/completion status on the following:

- (1) Helium system, moderator purification system, resin transfer, deuteration and dedeuteration system.
- (2) Regulating system such as absorber rods, shim rods, adjuster rods, zonal control.
- (3) Filling of suppression pool to the required level and keeping suppression pool poised.
- (4) Containment systems including engineered safety features, viz. containment isolation, containment post accident heat removal, depressurisation system, filtration and pump back system, secondary containment filtration and purge system.
- (5) Procedure for addition of D₂O to moderator and related auxiliary systems including special precautions and administrative controls to ensure adequate poison concentrations in the moderator.
- (6) Status on pending items and review of earlier decisions.
- (7) Commissioning of seismic instrumentation.

2. Phase B:

First approach to criticality and low power physics tests and experiments

Applicant should submit reports/completion status on the following.

- (1) Regulating and protection systems essential for low power operation and safety systems operability.
- (2) Pending items and earlier decisions till date.
- (3) Liquid poison system and secondary shutdown systems.
- (4) Emergency core cooling system.
- (5) Water chemistry control on PHT, moderator and other systems.
- (6) Failed fuel monitoring systems.

- (7) Fuel handling system including spent fuel storage
- (8) Rechecking/testing of RB ventilation isolation dampers, main airlocks and emergency airlocks.
- (9) Establishment of exclusion boundary and other site requirements.
- (10) On-site and off-site emergency procedures and report of an off-site emergency drill.
- (11) Exact procedure for first approach to criticality and low power physics measurements, including calibration and actual worth of various regulating and protection devices.
- (12) Phases B and C commissioning procedures and arrow diagram including measurements of reactivity worth of various control and protection elements/systems under different configurations.
- (13) Class IV power failure test.
- (14) Commissioning of emergency control room (ECR)
- (15) Mock up training for first approach to criticality.
- (16) Commissioning report on
 - (i) Initial fuel loading.
 - (ii) Heavy water addition (limited quantity to moderator, addition to PHT system and bulk addition in moderator system).
 - (iii) PHT circulation at low pressure and moderator system operation, isotopic and poison checkups.
- (17) Reactor trip and setback settings during criticality and low power physics measurements.
- (18) Status of system transfer documents.
- (19) Status of operating, safety and design documents.
- (20) Test results on emergency power supplies onsite.

3. Phase C:

Initial system performance tests at low, medium and rated power levels as determined by the stable operation of the turbine

Reactor power raise to 100% will be consented in following steps:

- (1) 1st step : Raise nuclear steam by increasing reactor power (up to 50% FP) of the unit. Following information will be supplied to the safety committee at this stage.

- (a) Results of Class IV power failure test.
 - (b) Status on deficiencies/pending jobs.
 - (c) Status on completion of various prerequisites/activities for raising power in Phase C of commissioning schedule.
 - (d) Review of TG and auxiliaries as per the overall commissioning activities chart.
 - (e) Issue Phase B commissioning report.
 - (f) Net load rejection test.
 - (g) Gross load rejection test.
- (2) 2nd step : Consent for synchronization and power operation up to 90% FP. Information to be supplied to safety committee is as follows.
- (a) Status on pending items.
 - (b) Report on reactor operation data at 50% FP.
 - (c) Issue Phase C commissioning report at 50% FP.
- (3) 3rd step : Provisional consent to operate up to 100% FP.
- (a) Status on pending items.
 - (b) Report on operating data collected at 90% FP; extrapolation to 100% FP and comparison with design data. Explanation of deviation, if any, from design intent.
 - (c) Issue of Phase C commissioning report containing performance test data collected on.
 - (i) Moderator and its auxiliaries, reactor auxiliary system (include end shield cooling system, CV cooling systems and annulus gas monitoring system).
 - (ii) Regulating and protection systems.
 - (iii) Sequence followed for raising power.
 - (iv) Data collected on electrical systems (MG, DG and battery to be included).
 - (v) ID and ND tower systems, common processes.
 - (vi) Liquid and gaseous activity releases/effluents.

- (vii) Station systems response checks for disturbances;
- (viii) Shutdown cooling capability test at around 2% FP
- (ix) Capability of FM supply pumps to give the design flow to bleed condenser, in addition to emergency gland supply flow.
- (x) PHT system cool down rate test as with different combination of shutdown cooling pumps and HXs.
- (xi) Hot boiler draining bypassing the bleed condenser as per design.
- (xii) Secondary systems and associated transient tests.
- (xiii) Ramp power increase/decrease (by 2% FP).
- (xiv) Reactor setback (for 10 seconds).
- (xv) Net load rejection test.
- (xvi) Gross load rejection test.
- (xvii) Turbine trip testing, etc.

APPENDIX-5
(Refer Section 2.2.5)

**DOCUMENTARY SUBMISSIONS IN SUPPORT
OF APPLICATION FOR CONSENT FOR
OPERATION - TYPICAL FOR PHWR**

- (i) Report on performance of the plant operation within the commissioning consenting period.
- (ii) Report on pending issues
- (iii) Report on performance of fuel handling system
- (iv) Report on status of documentation
- (v) Submission of SAR(F)

APPENDIX-6

(Refer Sections 5.2 & 5.3)

TYPICAL LEVEL OF REVIEW FOR SITING AND CONSTRUCTION STAGES

Stage	Activity	Review to be conducted by :
Siting	Clearance for Location of NPP at Proposed Site	First, Second & Third Tier Committees
Construction	Consent for construction in single stage or Consent for construction in sub-stages	First, second & third tier committees
	• Site excavation	First tier committee
	• First pour of concrete	First, second & third tier committees
	• Erection of major equipment	First, second & third tier committees

Note : Currently

- (1) The first tier committees are Site Evaluation Committee (SEC), Project Design Safety Committee (PDSC) and Civil Engineering, Safety Committee (CESC)
- (2) The second tier committee is the Advisory Committee on Project Safety Review (ACPSR)
- (3) The third tier committee is the Apex Board of AERB, i.e. the Atomic Energy Regulatory Board, AERB.
- (4) The reviewing bodies, depending on the situation, can increase the intermediate stages.

APPENDIX-7

(Refer Section 5.4)

TYPICAL LEVEL OF REVIEW FOR VARIOUS COMMISSIONING STAGES OF PHWR

Phase	Intermediate Stages of Commissioning *		Review to be conducted by
	No.	Activity	
A	i	Hot conditioning or passivation of the primary system and light water commissioning	First tier committee
	ii	Fuel loading of the reactor core, and part borated heavy water addition to storage, cooling and moderator systems, for flushing in specified limited quantity, during which criticality is not possible.	„
	iii	Addition of heavy water to primary heat transport system: and	„
	iv	Bulk addition of heavy water to moderator system with minimum specified boron level in heavy water to prevent criticality	First, second and third tier committees.
B	i	First approach to criticality	First, second and third tier committees.
	ii	Low power reactor physics tests and experiments	First and second tier committees.
C	i	Initial system performance tests at 50% FP, 90% FP and rated power levels, as determined by the stable operation of the turbine, and	First and second tier committees.
	ii	System performance at rated power.	First, second and third tier committees.

Note : Currently

1. The first tier committee is the Project Design Safety Committee (PDSC)
2. The second tier committee is the Advisory Committee on Project Safety Review (ACPSR)
3. The third tier committee is the Apex Board of AERB, i.e. the Atomic Energy Regulatory Board, AERB.

* The intermediate stages can be increased by the reviewing bodies depending on the situation.

APPENDIX-8

(Ref: Section 6.4)

LIST OF AERB CODES AND GUIDES

(A) List of Safety Code and Guides on Regulation of Nuclear and Radiation Facilities

Safety Series No.	Title
AERB/SC/G	Regulation of Nuclear and Radiation Facilities.
AERB/NPP&RR/SG/G-1	Consenting Process for Nuclear Power Plants and Research Reactors
AERB/NF/SG/G-2	Consenting Process for Nuclear Fuel Cycle Facilities and Related Industrial Facilities other than Nuclear Power Plants and Research Reactors
AERB/RF/SG/G-3	Consenting Process for Radiation Facilities
AERB/SG/G-4	Regulatory Inspection and Enforcement in Nuclear and Radiation Facilities.
AERB/SG/G-5	Role of the Regulatory Body with Respect to Emergency Response and Preparedness at Nuclear and Radiation Facilities.
AERB/SG/G-6	Codes, Standards and Guides to be Prepared by the Regulatory Body for Nuclear and Radiation Facilities.
AERB/SG/G-7	Regulatory Consents for Nuclear and Radiation Facilities: Contents and Formats.
AERB/SG/G-8	Criteria for Regulation of Health and Safety of Nuclear Power Plant Personnel, the Public and the Environment
AERB/NPP&RR/SM/G-1	Regulatory Inspection and Enforcement in Nuclear Power Plants and Research Reactors
AERB/NF/SM/G-2	Regulatory Inspection and Enforcement in Nuclear Fuel Cycle Facilities other than Nuclear Power Plants and Research Reactors
AERB/RF/SM/G-3	Regulatory Inspection and Enforcement in Radiation Facilities.

APPENDIX-8 (CONTD.)

(Ref: Section 6.4)

LIST OF AERB CODES AND GUIDES (Contd.)

(B) List of Safety Codes and Guides on Nuclear Power Plant Siting

Safety Series No.	Title
AERB/SC/S	Code of Practice on Safety in Nuclear Power Plants Siting
AERB/SG/S-1	Atmospheric Dispersion and Modelling
AERB/SG/S-2	Hydrological dispersion of Radioactive Materials in Relation to Nuclear Power Plant Siting
AERB/SG/S-3	Extreme Values of Meteorological Parameters
AERB/SG/S-4	Hydrogeological Aspects of Sitings of Nuclear Power Plants
AERB/NF/SG/S-5	Methodologies for Environmental Radiation Dose Assessment
AERB/SG/S-6A	Design Basis Flood for Nuclear Power Plants on Inland Sites
AERB/SG/S-6B	Design Basis Flood for Nuclear Power Plants at Coastal Sites
AERB/NPP/SG/S-7	Man Induced Events and Establishment of Design Basis
AERB/NPP/SG/S-8	Site Considerations of Nuclear Power Plants for Off-site Emergency Preparedness
AERB/SG/S-9	Population Distribution and Analysis in Relation to Siting of Nuclear Power Plants
AERB/NPP/SG/S-10	Quality Assurance in Siting of Nuclear Power Plants
AERB/SG/S-11	Seismic Studies and Design Basis Ground Motion for Nuclear Power Plant Sites

APPENDIX-8 (CONTD.)

(Ref: Section 6.4)

LIST OF AERB CODES AND GUIDES (Contd.)

(C) List of Safety Codes, Guides and Manuals on Design of Pressurised Heavy Water Reactor

Safety Series No.	Title
AERB/SC/D	Code of Practice on Design for Safety in Pressurised Heavy Water Reactor Based Nuclear Power Plants
AERB/SG/D-1	Safety Classification and Seismic Categorisation for Structures, System and Component of Pressurised Heavy Water Reactors
AERB/SG/D-2	Structural Design of Irradiated Components
AERB/SG/D-3	Protection Against Internally Generated Missiles and Associated Environmental Conditions
AERB/SG/D-4	Fire Protection in Pressurised Heavy Water Reactor Based Nuclear Power Plants
AERB/SG/D-5	Design Basis Events for Pressurised Heavy Water Reactors
AERB/SG/D-6	Fuel Design for Pressurised Heavy Water Reactors
AERB/SG/D-7	Core Reactivity Control in Pressurised Heavy Water Reactors
AERB/SG/D-8	Primary Heat Transport System for Pressurised Heavy Water Reactors
AERB/SG/D-9	Process Design
AERB/SG/D-10	Safety Systems for Pressurised Heavy Water Reactors
AERB/SG/D-11	Emergency Electric Power Supply Systems for Pressurised Heavy Water Reactor
AERB/SG/D-12	Radiation Protection Aspect in Design of Pressurised Heavy Water Reactor Based Nuclear Power Plants
AERB/SG/D-13	Liquid and Solid Radwaste Management of Pressurised Heavy Water Reactor Based Nuclear Power Plants
AERB/SG/D-14	Control of Air-borne Radioactive Materials in Pressurised Heavy Water Reactors

APPENDIX-8 (CONTD.)

(Ref: Section 6.4)

LIST OF AERB CODES AND GUIDES (Contd.)

(C) List of Safety Codes, Guides and Manuals on Design of Pressurised Heavy Water Reactor (Contd.)

Safety Series No.	Title
AERB/SG/D-15	Ultimate Heat Sink and Associated Systems in Pressurised Heavy Water Reactor
AERB/SG/D-16	Materials Selection and Properties
AERB/SG/D-17	Design for In-Service Inspection
AERB/SG/D-18	Loss of Coolant Accident Analysis for Pressurised Heavy Water Reactor
AERB/SG/D-19	Deterministic Safety Analysis of Pressurised Heavy Water Reactor Based Nuclear Power Plants
AERB/NPP-PHWR/ SG/D-20	Safety Related Instrumentation and Control for Pressurised Heavy Water Reactor Based Nuclear Power Plants
AERB/SG/D-21	Containment System Design for Pressurised Heavy Water Reactor
AERB/SG/D-22	Vapour Suppression System for Pressurised Heavy Water Reactor
AERB/SG/D-23	Seismic Qualification of Structures, Systems and Components of Pressurised Heavy Water Reactor Based Nuclear Power Plant
AERB/SG/D-24	Design of Fuel Handling and Storage Systems for Pressurised Heavy Water Reactor
AERB/SG/D-25	Computer Based Safety Systems of Pressurised Heavy Water Reactor Based Nuclear Power Plants
AERB/SM/D-1	Decay Heat Load Calculation for Pressurised Heavy Water Reactor Based Nuclear Power Plants
AERB/NPP-PHWR/ SM/D-2	Hydrogen Release and Mitigation Measures under Accident Condition in Pressurised Heavy Water Reactor

APPENDIX-8 (CONTD.)

(Ref: Section 6.4)

LIST OF AERB CODES AND GUIDES (Contd.)

(D) List of AERB Safety Codes, Guide and Manuals on Operation of Nuclear Power Plants

Safety Series No.	Title
AERB/SG/O	Code of Practice on Safety in Nuclear Power Plant Operation
AERB/SG/O-1	Staffing, Recruitment, Training, Qualification and Certification of Operating Personnel of Nuclear Power Plants.
AERB/SG/O-2	In-Service-Inspection of Nuclear Power Plants
AERB/SG/O-3	Operational Limits and Conditions for Nuclear Power Plants
AERB/SG/O-4	Commissioning Procedures for Pressurised Heavy Water Reactor Based Nuclear Power Plants
AERB/SG/O-5	Radiation Protection During Operation of Nuclear Power Plants
AERB/SG/O-6	Preparedness of Operating Organisation for Handling Emergencies at Nuclear Power Plants
AERB/SG/O-7	Maintenance of Nuclear Power Plants
AERB/SG/O-8	Surveillance of Items Important to Safety in Nuclear Power Plants
AERB/SG/O-9	Management of Nuclear Power Plants for Safe Operation
AERB/SG/O-10A	Core Management and Fuel Handling in Operation of Pressurised Heavy Water Reactors
AERB/SG/O-10B	Core Management and Fuel Handling in Operation of Boiling Water Reactors
AERB/SG/O-11	Management of Radioactive Waste Arising From Operation of Pressurised Heavy Water Reactor Based Nuclear Power Plants
AERB/SG/O-12	Renewal of Authorisation for Operation of Nuclear Power Plants

APPENDIX-8 (CONTD.)

(Ref: Section 6.4)

LIST OF AERB CODES AND GUIDES (Contd.)

(D) List of AERB Safety Codes, Guide and Manuals on Operation of Nuclear Power Plants

Safety Series No.	Title
AERB/SG/O-13	Operational Safety Experience Feedback on Nuclear Power Plants
AERB/NPP/SG/O-14	Life Management of Nuclear Power Plants
AERB/NPP/SG/O-15	Proof and Leakage Rate Testing of Reactor Containments
AERB/NPP-PWR/ SG/O-16	Commissioning of Pressurised Water Reactor Based Nuclear Power Plants
AERB/NF/SM/O-1	Probabilistic Safety Assessment Guidelines
AERB/NF/SM/ O-2 (Rev. 4)	Radiation Protection for Nuclear Facilities
AERB/NPP/TD/O-1	Compendium of Standard Generic Reliability Database for Probabilistic Safety Assessment of Nuclear Power Plants

APPENDIX-8 (CONTD.)

(Ref: Section 6.4)

LIST OF AERB CODES AND GUIDES (Contd.)

(E) List of Code and Guides on Quality Assurance

Safety Series No.	Title
AERB/SC/QA	Code of Practice on Quality Assurance for Safety in Nuclear Power Plants
AERB/SG/QA-1	Quality Assurance in the Design of Nuclear Power Plants.
AERB/SG/QA-2	Quality Assurance in Procurement of Items and Services for Nuclear Power Plants.
AERB/SG/QA-3	Quality Assurance in the Manufacture of Items for Nuclear Power Plants.
AERB/SG/QA-4	Quality Assurance During Site Construction of Nuclear Power Plants.
AERB/SG/QA-5	Quality Assurance During Commissioning and Operation of Nuclear Power Plants.
AERB/NPP/SG/QA-6	Establishing and Implementing Quality Assurance Program for Nuclear Power Plants
AERB/NPP/SG/QA-7	Assessment of Implementation of Quality Assurance Programme in Nuclear Power Plants
AERB/NPP/SG/QA-8	Non-conformance Control, Corrective and Preventive Actions for Nuclear Power Plants
AERB/NPP/SG/QA-9	Document Control and Records Management for Quality Assurance in Nuclear Power Plants

APPENDIX-9

(Ref: Section 2.2.3)

SUBJECTS OF SAR (P) FOR REVIEW FOR VARIOUS SUBSTAGES WITHIN CONSTRUCTION CONSENT

I FOR EXCAVATION CLEARANCE

(1) General Description of Plant: Safety and Seismic Classification

- Overall Philosophy
- Overall plant summary description covering plant layout, reactor systems and auxiliaries and safety systems.
- Safety, seismic and quality classification of components, systems and structures; their bases, categories; tabulations giving detailed classification list.
- General design criteria for mechanical/electrical/instrumentation/safety and safety related systems, seismic design and qualification criteria for category-1 (SSE) systems and environmental design principles.
- Overview of quality assurance in design, manufacture, construction, commissioning and operation.

(2) Siting and Environmental Data

- Site location: Geographical location indicating distance/direction with respect to major towns/landmarks, location map, access roads/routes covering at least 50 km from the facility.
- Geological setting and tectonic set up; effect on design of foundation and structures.
- Geotechnical investigation and evaluation of foundation parameters.
- Seismic design basis, parameters covering the data base used, regional geology and tectonic, earthquake occurrence history. Applicable attenuation law for peak ground acceleration. PGAs for S1 (OBE) and S2 (SSE) levels, PGA response spectra, spectral compatible accelograms.
- Topography and ground-water conditions of the site area.
- Meteorological and environmental data which affect plant

design and gaseous radioactive effluents, viz. wind speed, direction and duration (wind roses), data for design basis wind loads, precipitation, peculiarities of local meteorological conditions, including effect of terrain which could have impact on diffusion of radioactive releases.

- Population distribution in 16 km zone; exclusion and sterilization zones; available shelter facilities.
- Nature of land use and produce.
- Water utilisation and irrigation.
- Flood.
- Shore line erosion.
- Waste management overall philosophy covering solid waste management, effluent treatment and water utilisation.
- External man induced events.

(3) Building and Structures

- Layout of plant bringing out location of all building and structures.
- Layout of equipment of safety system and safety related systems including requirements of in-service inspection (ISI), nuclear security, fire safety, radiation zoning, internal events etc.
- Safety and other special requirements for various structures including containment.
- Specific special requirements (affecting layout) considering the bulk shielding for reactor systems/components/equipment and their layout considering their shielding aspects.
- Grade level, flood prevention and drainage system
- Access roads, escape routes.

II FOR 'FIRST POUR OF CONCRETE (FPC)' CLEARANCE

(4) Reactor, Steam Generator and Auxiliaries

- Overall general description of reactor system
- Reactor auxiliary systems
- Station heat balance for normal 100% FP operation.
- Reactor and its components - design and construction
- Reactor coolant and associated system

- Moderator system
- Engineered safety systems
- Shutdown and protection systems

(5) Fuel and Fuel Handling

- Fuel design
- Fuel handling system
- Fuelling machines

(6) Control and Instrumentation

- Design criteria and design bases for C&I Systems.
- Special requirements for instruments of safety systems and safety related systems.
- Control centre and their equipment covering the main control room and supplementary control centre. Computer systems used for control or protection, provisions for protection against faults in hardware/software.
- Operator information systems and operator aids.
- An instrumentation plan.
- Overall plant control and control programs.
- Reactor regulation/reactivity control; control aspects of various reactivity devices, flux tilt control/zone control.
- Reactor protection/shutdown systems (C&I Aspects) : design objectives, system description covering sensors, trip logic and instrumentation, PSS(SDS1), SSS(SDS2), and moderator liquid poison addition systems.
- Devices for measuring reactor power and their calibrations.
- Startup instruments.
- Instrumentation for process systems covering monitoring, controls and protective actions for various parameters of moderator and PHT Systems; PHT pressure control including IRVs, SG pressure control, SG level control, turbine generator control, deaerator level control, bleed condenser pressure and level control, etc.
- Heavy water leak detection system.
- Radiation monitoring systems (area monitors, contamination monitors, personnel and environmental monitors).

- Instrumentation for engineered safety features/accident mitigation systems.
- Instrumentation for ECCS, small leak handling.
- Failed fuel detection systems.
- Instrumentation for containment including instrumentation for accident conditions.
- Control power supplies and distribution.
- Instrument air.

(7) Plant Services

- Process water system (active and non-active)
- Fire fighting water system
- Ultimate heat sink for emergency conditions
- Condenser cooling water systems and domestic water systems
- Drainage system
- Ventilation systems for primary and secondary containment
- Containment related engineered safety features (containment isolation systems, PC filtration and pump back system, primary containment controlled discharge system, secondary containment re-circulation purge system). Functional requirements/design basis and systems description including key parameters.
- Ventilation system for service building and turbine building; control room ventilation including emergency ventilation for control room habitability.
- Station service electrical system
- Compressed air systems (instrument air, service air, mask air)
- Fire protection systems
- Communication systems- within plant and with outside agencies.

(8) Radiation Hazards Control and Radioactive Waste Management

(8)A Radiation Hazards Control

- Provisions for exclusion zone, sterilized zone, etc.
- Design/expected radiation levels in various plant areas.
- Access control - Functional requirements and provisions including door interlock system.

- Contamination control : zoning system (philosophy and details; control of personnel movement; operating island).
- Radiation monitoring and alarms : functional requirements and details of monitors, their types, ranges and locations.
- Provisions for off-site check of contamination - ESL and its objectives.
- Emergency planning- philosophy and overview covering various types of emergencies (give reference to the detailed emergency manual).

(8)B Radioactive Waste Management

- Overall philosophy of the radioactive waste management scheme.
- Solid radioactive waste.
- Radioactive liquid wastes
- Active gaseous waste

(9) Reactor Physics and Shielding

- Overall description of core design including fuel, D₂O, reactor control devices and shutdown systems.
- Reactor core characteristics during various phases from initial core to equilibrium conditions.
- Flux profiles and channel power distribution.
- Worth of regulation and protection devices and rates of insertions/withdrawal.
- Reactivity coefficients: fuel temperature, power, void, moderator; moderator purity effect, coolant purity effect, coolant temperature, moderator temperature effect.
- Xenon load transients for various power level changes.
- Shutdown reactivity margins under normal and accident conditions
- Fuel management objectives and channel selection aspects.

(9)A Shielding

- Radiation sources; design specified/expected dose rates in various areas.
- Description of shielding provision for β , γ and neutrons and other design considerations. Covering shielding of

reactor vaults, FM service area, fuel transfer rooms, moderator room, PHT system equipment, various penetrations and any other sources of radiation in reactor building.

- Circuit activities in PHT coolant, moderator and other active circuits.
- Local shielding requirements outside reactor building including spent fuel transfer tube and their details.

(10) Shared Systems

- Identification of systems, which are shared by more than one unit at the station.
- Safety implications of the sharing feature. Specifically capability to handle accident in one unit and orderly shutdown in the other unit(s) should be brought out.

(11) QA Program

- Organisation and responsibilities
- QA during design phase
- QA in procurement
- QA in manufacturing
- QA during site construction
- QA during site construction – contractors' work
- QA during commissioning
- QA during operation.

(12) Nuclear Security

- Physical protection system covering access control detection, alarm and assessment, delay and physical barrier, communication, plant configuration, etc.

III FOR 'ERECTION OF MAJOR EQUIPMENT' CLEARANCE

(13) Safety Analysis Report (Accident Analysis)

- General considerations bringing out safety objectives and principles and an overview of the safety features of the plant (both inherent and engineered), which have a bearing on prevention of initiating events and their mitigation.
- Dose criteria and limits: authorised/acceptable releases for normal operation and accident conditions and their bases.

- Safety analysis for postulated initiating events within the design bases as per AERB guide (AERB/SG/D-5).

(14) TG and Electrical Output System

- Main steam system and secondary cycle including steam mains, condensing system, condensate and steam water systems, and steam dump, discharge and relief systems.
- Steam turbine, its CIES and governor valve systems, governing and protection systems; permissible frequency ranges for turbine operation; turbine missile prevention.
- Turbine lubrication systems and bearings.
- Generator and auxiliaries including hydrogen cooling, seal oil systems, static excitation systems and protection.
- Turbine generator control and protection including list of trips and annunciations.

(15) Commissioning Aspects and Commissioning Programme

- Scope of commissioning activities.
- Organisations involved and their responsibilities.
- Commissioning phases.
- Preparatory work involved, e.g. preparation of documents, procurement of spares, setting up of reference facilities, training.
- Commissioning work sequence, e.g. equipment testing, pre-service inspection, system transfers, pre-operational checks, logic checks, performance tests, etc.
- Commissioning program to be carried out covering major milestones starting from pre-criticality to start of commercial operation.
- Commissioning reports.

(16) Operating Aspects and Station Organisation

- Station organisation (should include functional description of each group as per the organisation such as technical group, O&M group, QA group, radiation protection supervision, etc.).
- Training (should include curriculum, level of training, qualification method, qualification program, training centre etc.)
- Operation during commissioning.

- Operating documents.
- Industrial safety.
- Security plan.
- Emergency plan.

(17) Submissions of reports/detailed notes on the following areas/ topics

- Validation of computer codes used design and safety evaluation
- Seismic and environmental qualification aspects for safety related structures, equipment and components and the acceptance criteria
- Safety significant observations made during manufacture of safety related structures, equipment and components
- Pre and post installation preservation methods for safety related equipment and components
- Operating experience feed back
- Basis of acceptance for innovative (first of its kind) systems

Additional notes on areas/topics, if considered important for safety review by PDSC/CESC/ACPSR should also be addressed for review as per Sections 4.3 and 4.4 of the guide.

ANNEXURE-1

GENERAL GUIDELINES FOR REVIEW AND ASSESSMENT OF PSA

AERB should review and assess the PSA to gain confidence that it has been carried out, as per the established quality assurance program, to an acceptable standard, so that the result can be used as an input to the risk-informed decision making process. In the review and assessment, it should be ensured that the data used in estimating magnitudes and/or frequencies of parameters such as system unreliability, core damage frequency, radioactive release from the plant and public risk are well founded, PIEs considered for analysis are appropriately grouped and represented, are comprehensive and uncertainties in the estimates are identified and quantified with standard methodology and risk worked out are acceptable.

In this regard, probabilistic safety goals as established, based on experts' opinions and current international practices, and acceptable to AERB, should be considered. These are, for example, as proposed by INSAG-3 :

Core damage frequency -	10^{-4} per reactor year (R-Y) for existing plant
	10^{-5} /R-Y for new plant
Large early radioactivity release frequency -	10^{-5} /R-Y for existing plant
	10^{-6} /R-Y for new plant

Since the objective of PSA is to identify weaknesses in the design, evaluate impact of proposed changes and provide demonstration that safety requirements are met and risk from the operation of plant is acceptably low, it should be ensured that data used for the analysis have sound basis, are relevant to the plant and uncertainties are appropriately accounted for.

ANNEXURE-2

APPLICATION FORMAT

FORM A

APPLICATION FOR SITING CONSENT

(Stage for which consent is asked for)

PART A

GENERAL PARTICULARS

1. Name of the Applicant in full :
(in block letters)
2. Full Name and Postal Address of the Institution, with Pin Code:
.....
.....
.....
3. Designation of the Applicant:
4. Mode of Communication :
 - I Telephone : Office :
Residence:
 - II Fax Number :
 - III E-mail ID :
5. Location of the Project:
 - I Proposed Site : New / Existing
 - II Site Address :
.....
.....
 - III Nearby Plants (NPPs/HWPs/Other Plants or Facilities) within
Emergency Planning Zone(EPZ):
.....
.....

ANNEXURE-2 (CONTD.)

6. Type of Project:
- I Reactor Type : PHWR/PWR/FBR (Any Other Type)
- II Plant Design : New / Repeat
- Reference Plant
(In case of Repeat Design) :
- III Electrical Capacity :MWe
7. Consent Sought for Unit(s) No(s). :
8. Present Stage of Consent :
9. Tentative Schedule for
Commencement of Activity :
(With due consideration for Lead Time
as per Sec. 3.22 of AERB/NPP/SG/G-1)

PART-B

INFORMATION TO BE FURNISHED FOR SITING CONSENT

1. Site Evaluation Report (contents as detailed in Appendix-1 of AERB/SG/G-1)
(Lead time for submission/ availability of document shall be as indicated in
section 3.22 of AERB Safety Guide AERB/NPP/SG/G-1)

PART C

CERTIFICATE

I hereby certify that the information furnished above is correct to the best of
my knowledge and belief.

ANNEXURE-2 (CONTD.)

UNDERTAKING

I undertake to :

1. fulfill all the conditions and requirements to be stipulated in the consent.
2. keep AERB informed of any changes in the information furnished above.
3. abide by the instructions/ directions of AERB.
4. fulfill all other relevant requirements prescribed in the Atomic Energy Act, 1962 and the rules issued thereunder, and in the relevant codes.
5. meet the requirements prescribed in other relevant statutes.

Date:

(Signature)

ANNEXURE-2 (CONTD.)

FORM A

APPLICATION FOR CONSTRUCTION CONSENT

(for a single consent)

PART B

INFORMATION TO BE FURNISHED

(For lead time for submission/availability of documents and contents see Section 3 of AERB/NPP/SG/G-1)

1. Preliminary safety analysis report (contents as detailed in Appendix-2 of the AERB safety guide AERB/NPP/SG/G-1). Reviews of Parts I, II and III of Appendix-9 to be completed before construction consent.
 2. Applicant's site construction QA manual
 3. Construction schedule for the proposed nuclear power plant (NPP), excavation drawings and procedures, report on site grading and surface drainage, confirmatory geotechnical investigation report, report on concrete mix design and construction methodology document.
 4. Design basis reports (contents as detailed in Section 3.4 of the AERB safety guide AERB/NPP/SG/G-1).
 5. Design reports of items important to safety having relevance to construction consent.
 6. Report on design basis ground motion, geo-technical investigations, and foundation parameters for meteorological events.
 7. Selected design reports for civil engineering structures important to safety, as identified by concerned committee.
 8. Details of construction labour colony (for existing sites)
 9. Location and approach/exit roads
 10. Job hazard analysis report
 11. Emergency preparedness plan (for existing sites)
 12. Construction safety management manual
 13. Plant and site security aspects
- Note : Part A and Part C in all applications will be same as in the application for siting consent.

ANNEXURE-2 (CONTD.)

FORM A

APPLICATION FOR SITE EXCAVATION CONSENT

PART B

INFORMATION TO BE FURNISHED

1. Details of Siting Consent:

Stage	Date of Consent	Status of compliance to stipulations made by SEC/ACPSR/AERB
Siting		

2. Details of Submissions (For lead time and contents see Section 3 of AERB/NPP/SG/G-1)

- I Details of submissions for industrial safety:
 - I.A. Job hazard analysis report
 - I.B. Construction safety management manual
- II Preliminary safety analysis report
(Contents as detailed in Appendix-2 of AERB/NPP/SG/G-1)
Review of Part I of Appendix-9 of AERB/NPP/SG/G-1 to be completed before excavation clearance.
- III Design basis reports and design reports for items important to safety
- IV Plant layout and site grading
- V Report on design basis ground motion parameters, geo-technical investigations and foundation parameters, meteorological parameters
- VI Design basis reports (including dynamic analysis methodology) of civil engineering structures/buildings important to safety:
- VII Excavation drawings and procedures
- VIII Excavation schedule for the proposed nuclear power plant (NPP)

ANNEXURE-2 (CONTD.)

- IX Details of construction labour colony (for existing sites)
Location and approach/exit roads: with respect to the construction labour colony
- X Emergency preparedness plan (for existing sites)

Note : Part A and Part C in all applications will be same as in the application for Consent for Siting.

ANNEXURE-2 (CONTD.)

FORM A

**APPLICATION FOR FIRST POUR OF
CONCRETE CONSENT**

PART B

INFORMATION TO BE FURNISHED

1. Details of Siting Consent:

Stage	Date of Consent	Status of compliance to stipulations made by SEC/ ACPSR/AERB
Siting		

2. Details of Excavation Consent

Stage	Date of Consent	AERB Stipulations Status
Siting		

- I Date of Commencement of Excavation:
- II Status of Excavation: Completed/ Not Completed
- Schedule for excavation completion
if it is not completed (mention areas
and reason for delay)
- III Any Special Observations during Excavation
-
-
- Any clearance required from AERB
for any special observation during
excavation : Yes / No
- Status of such clearance : Obtained / Not Obtained

ANNEXURE-2 (CONTD.)

3. Details of Submissions (for lead time and contents see Section 3 of AERB/NPP/SG/G-1)
- I Job hazard analysis report
 - II Construction schedule for the proposed nuclear power plant (NPP)
 - III Preliminary safety analysis report (Contents as detailed in Appendix-2 of AERB/NPP/SG/G-1). Review of Part II of Appendix-9 to be completed before FPC clearance
 - IV Submission of responses/documents as required based on SAR (P) review
 - V Status of pending issues based on earliest stage reviews
 - VI QA Manual for design
 - VII DBR on surface drainage, confirmatory geo-technical investigation report, geological mapping of the excavated foundation pits
 - VIII DBRs (including dynamic analysis methodology) of civil engineering structures important to safety (those DBRs which have not been submitted before excavation clearance). Provisions for short term and long term structural instrumentation and monitoring, if any, should be included in the respective DBR.
 - IX Dynamic analysis reports and selected design reports, for civil engineering structures important to safety as identified by CESC
 - X Report on concrete mix design
 - XI Construction methodology document
 - XII Quality assurance manual for site construction and contractors QA document
 - XIII Details of construction labour colony (for existing sites)
 - XIV Location and approach/exit roads
 - XV Emergency preparedness plan (for existing sites) covering project construction personnel (radiation emergency as well as emergency arising due to other facilities such as toxic gas release, etc.)

Note : Part A and Part C in all application will be same as in the application for Consent for Siting.

ANNEXURE-2 (CONTD.)

FORM A

**APPLICATION FOR ERECTION OF MAJOR
EQUIPMENT CONSENT**

PART B

INFORMATION TO BE FURNISHED

1. Details of Siting Consent:

Stage	Date of Consent	Response to stipulations of SEC/ACPSR/AERB
Siting		

2. Details of Excavation Consent:

Stage	Date of Consent	AERB Stipulations Status
Siting		

- I Date of Commencement of Excavation :
- II Status of Excavation: Completed/ Not Completed
- Date of completion of excavation:
- Schedule for excavation completion,
if it is not completed
(Mention areas and reason for delay)
- III Any Special Observation during Excavation
.....
.....
- Any clearance required from AERB
for any special observation during
excavation : Yes / No
- Status of such clearance : Obtained / Not Obtained

ANNEXURE-2 (CONTD.)

3. Details of First Pour of Concrete (FPC) Consent

Stage	Date of Consent	AERB Stipulations Status
FPC		

- I Date of Commencement of FPC :
- II Status of FPC : Completed / Not Completed
- Status of construction of safety
 related building along with
 important structures :
- Schedule of completion of civil
 structures :
- If it is not completed (mention
 areas and reasons for delay)
- III Any special observation during FPC
-
-
- Any clearance required from AERB
 for the special observation during
 FPC : Yes / No
- Status of such clearance : Obtained / Not obtained

4. Details of Submissions (For Lead Time and contents see Section 3 of AERB/NPP/SG/G-1)

- I Job hazard analysis report.
- II Schedule for erection of major equipment for the proposed nuclear power plant (NPP)
- III Preliminary Safety Analysis Report (Contents as detailed in Appendix-2 of AERB/NPP/SG/G-1). Review of Part II of Appendix-9 to be completed before equipment erection clearance.
- IV Submission of responses/documents as required based on SAR (P) review
- V Status of pending issues based on earlier stage reviews.

ANNEXURE-2 (CONTD.)

- VI Design basis reports and design reports for items important to safety
- VII DBR (including dynamic analysis methodology) of civil engineering structures important to safety (DBRs which have not been submitted prior to clearance for excavation and FPC)
- VIII Dynamic analysis reports and selected design reports for civil engineering structures important to safety as identified by CESC (design reports which have not been submitted prior to clearance for excavation and FPC)
- IX Other requirements
- IXA Details of labor colony (for existing sites)
Give the status of the following.
Location and approach/exit roads
- IXB Status of emergency preparedness (for existing sites):
(radiation emergency as well as emergency arising due to other facilities such as toxic gas release, etc.)
- IXC Plant and site security aspects (confidential)

Note : Part A and Part C in all applications will be same as in the application for Consent for Siting.

ANNEXURE-2 (CONTD.)

FORM A

APPLICATION FOR COMMISSIONING CONSENT

PART-B

INFORMATION TO BE FURNISHED

1. Schedule for commissioning program
2. Organisation for operation and commissioning (Section 3.12 of AERB/NPP/SG/G-1)
3. Quality assurance manual for commissioning and operation based on the requirements specified in AERB code and guides on QA (Appendix 8 of AERB/NPP/SG/G-1)
4. Organisational structure and division of responsibility (Ref: Section 3.15.2 of AERB/NPP/SG/G-1)
5. Training and qualification program (including schedule for licensing key operating personnel- training document (Ref: Section 3.16 of AERB/NPP/SG/G-1)
6. Technical specifications for operation (Ref: Section 3.14 of AERB/NPP/SG/G-1)
7. In service inspection and testing program- manual (Ref: Section 3.18 of AERB/NPP/SG/G-1)
8. Radiation protection procedure (Ref: Section 3.19 of AERB/NPP/SG/G-1)
9. Emergency plans (on site and off site) (Ref: Section 3.15.3 of AERB/NPP/SG/G-1)
10. Records (Ref: Section 3.15.5 of AERB/NPP/SG/G-1)
11. Information on physical protection (Confidential) (Ref: Section 3.21 of AERB/NPP/SG/G-1)
12. Waste management operating manual
13. Fire hazard analysis

ANNEXURE-2 (CONTD.)

14. Fire order with available provisions
15. Training documents
16. Maintenance procedures
17. Emergency operating procedures (EOPs)
18. Commissioning related information covering system status and test results
(Contents as per Appendix 4 of the AERB safety guide AERB/NPP/SG/G-1)
19. Plant and site security aspects
20. Submission of responses/documents as required based on SAR(P) review.

(Note: Lead time for submissions/ availability of documents shall be as indicated in section 3.22 of the safety guide AERB/NPP/SG/G-1)

Note: Part A and Part C in all applications will be same as in the application for Consent for Siting.

ANNEXURE-2 (CONTD.)

FORM A

APPLICATION FOR CONSENT FOR OPERATION

PART B

INFORMATION TO BE FURNISHED

1. Submission as given in Appendix-5 for consent for operation

(Note: Lead time for submissions/ availability of documents shall be as indicated in section 3.22 of the safety guide AERB/NPP/SG/G-1)

Note: Part A and Part C in all applications will be same as in the application for Consent for Siting.

ANNEXURE-3

(Refer Part B of Appendix 2&3)

FORMAT AND CONTENT OF REPORTING DETERMINISTIC (ACCIDENT) ANALYSIS

1. Cover sheet (title, year/date, organisation name, etc.)
2. Preface
3. Table of contents
4. Summary report describing need, objective, scope of study, basis of PIE selection, acceptance criteria, overview of analysis approach and performance, methodology, computer codes, major findings and conclusions
5. Main report
 - 5.1 Introduction-background, objective and principles, scope, analysis basis and references, structure of report
 - 5.2 QA (management system) for accident analysis
 - 5.3 IEs-listing, categorisation and functional grouping
 - 5.4 Acceptance criteria- basic, secondary analysis criteria, relation to PIE categorisation
 - 5.5 Analysis approach/methodology conservative, best estimate, combinations, uncertainty and sensitivity analyses, assumptions, initial and boundary conditions, failure postulations, availability of normal operating systems/components
 - 5.6 Computer codes (state-of-the-art): verification and validation, documentation
 - 5.7 Analysis of selected PIEs
 - Title
 - PIE description, schematic to show its relevance/relation in plant system
 - Event causes
 - Categorisation
 - Functioning of normal operating system
 - Failure postulation-single failure criteria, supplementary failure in redundancies

ANNEXURE-3 (CONTD.)

- Plant logic/reactor scram/delay considerations in functioning
 - Nodalisation scheme, code used and its applicability and validation aspects
 - Initial and boundary conditions
 - Analysis performance and presentation of results, chronological event sequences
 - Description of salient observations, explanations of transient behavior (spike, trends, etc.)
 - Plots of all relevant parameters to time scale, with appropriate magnification to understand event phenomena and having bearing on acceptance criteria, etc.
- 5.8 Conclusion and recommendations
- Assessment of meeting of acceptance criteria, need for future work if any, agency to do the work and work schedule
- 5.9 Appendices/Annexures, definitions and abbreviations used
- 5.10 References and/or Bibliography
- 5.11 Peer review
- 5.12 Documentation
6. System for continual improvement.

ANNEXURE-4

FORMAT AND CONTENT OF REPORTING PROBABILISTIC SAFETY ANALYSIS

1. Cover sheet (Title, year/date, organisation name etc)
2. Preface
3. Table of contents
4. Summary report(describing need/genesis, objective, scope of the study, basis of IEs selection, probabilistic goals, analysis approach, input reliability data used, analysis performance aspects including uncertainty, sensitivity studies, major findings and conclusions)
5. Main Report
 - 5.1 Introduction: background, objectives and principles, scope, structure of the report
 - 5.2 QA Programme (management system)
 - 5.3 Analysis approach (state-of-the-art) methodology and code used and performance results (may vary with subject, objective and level of the PSA study)

Aspects to be covered (Typical)

 - (1) PIEs considered, probabilistic safety goals
 - (2) System/plant description with suitable sketches as applicable
 - (3) Code used-applicability, validation, etc.
 - (4) Failure data used with bases, system unavailability (fault trees), accident sequences (event sequence diagram), core damage frequency, dominant contributions, plant vulnerabilities, etc. (level-2 PSA)

Containment failure mode, source term, grouping and their frequencies, plant vulnerabilities, etc. (level-2 PSA)

Radionuclides concentration at different locations and times, radiation dose, health effect, social impact, etc. (level-3 PSA)
 - (5) Uncertainties, importance and sensitivity analyses

ANNEXURE-4 (CONTD.)

- 5.4 Conclusions and recommendations
 - Assessment of meeting the goal (objective)
 - Need for future work, agency to do the work and work schedule
- 5.5 Appendices/annexures, definitions, abbreviations used
- 5.6 References and/or Bibliography
- 5.7 Peer review
- 5.8 Documentation
- 6.0 System for continual improvement.

BIBLIOGRAPHY

1. ATOMIC ENERGY REGULATORY BOARD, Code on Regulation of Nuclear and Radiation Facilities; AERB Safety Code No. AERB/SC/G, Mumbai, India, 2000.
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3. INTERNATIONAL ATOMIC ENERGY AGENCY, Conduct of Regulatory Review and Assessment during Licensing Process for Nuclear Power Plants; IAEA Safety Series No. 50-SG-G3, Vienna, 1980.
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5. INTERNATIONAL ATOMIC ENERGY AGENCY, Information to be Submitted in Support of Licensing Applications for Nuclear Power Plants; IAEA Safety Series No. 50-SG-G2, Vienna, 1979.
6. INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Assessment and Verification for Nuclear Power Plants - IAEA Safety Guide NS-G-1.2, Vienna, 2001.
7. ATOMIC ENERGY REGULATORY BOARD, Draft Safety Manual on PSA of Nuclear Power Plants and Research Reactors (AERB/NF/SM/O-1), Mumbai, India, July 2006.

LIST OF PARTICIPANTS

WORKING GROUP

Dates of meeting : July 5, 1995
February 5, 1996
February 27, 1996
March 8, 1996
October 10, 1997
October 14, 1997
November 5, 1997
November 27, 1997
January 21, 1998
June 29, 1999
October 8, 1999
November 2, 1999
February 22, 2000
March 14, 2000
May 21, 2001
June 7, 2001

Members and Invitees of Working Group:

Shri S.P. Singh (Chairman)	Formerly Head, NSD, AERB
Shri S.S. Bajaj	NPCIL
Dr. P.C. Basu	AERB
Dr. A.K. Ghosh	BARC
Shri L.V. Behari	NPCIL
Shri R. Chowudhary	BARC (Former)
Shri D.K. Dave	AERB (Former)
Shri S.A.H. Ashraf (Member-Secretary)	AERB

**ADVISORY COMMITTEE ON PREPARATION OF CODE AND
GUIDES AND ON GOVERNMENTAL ORGANISATION
FOR REGULATION OF NUCLEAR AND
RADIATION FACILITIES (ACCGORN)**

Dates of meeting :	January 24, 1997	May 05, 2000	May 17, 2000
	June 19-20, 2000	July 04 & 06, 2000	August 31, 2000
	October 10, 2000	January 23, 2001	February 6, 2001
	February 22, 2001	May 29, 2001	August 1,2&3, 2001
	September 11, 2001	September 12, 2001	December 13, 2001
	January 9 & 10, 2003	February 4, 2003	February 10, 2003
	October 17, 2003	June 21, 2004	March 13, 2006
	August 04, 2006		

Members and Invitees of ACCGORN:

Late Dr. S.S. Ramaswamy, Chairman (till September 2002)	Former Director General, Factory Advice Service and Labour Institute (FASLI)
Shri G.R. Srinivasan, Chairman	Former Vice Chairman, AERB
Shri G.V. Nadkarny	NPCIL (Former)
Shri A.K. Asrani	AERB (Former)
Shri T.N. Krishnamurthi	AERB (Former)
Late Dr. I.S. Sundara Rao	AERB (Former)
Shri N.K. Jhamb	AERB (Former)
Dr. K.S. Parthasarthy	AERB (Former)
Shri P.K. Ghosh	AERB
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**PROVISIONAL LIST OF CODE AND GUIDES ON
REGULATION OF NUCLEAR AND
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Published by : Atomic Energy Regulatory Board
Niyamak Bhavan, Anushaktinagar
Mumbai - 400 094
INDIA.

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