GOVERNMENT OF INDIA

AERB SAFETY GUIDE

QUALITY ASSURANCE DURING COMMISSIONING AND OPERATION OF NUCLEAR POWER PLANTS

ATOMIC ENERGY REGULATORY BOARD

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QUALITY ASSURANCE DURING COMMISSIONING AND OPERATION OF NUCLEAR POWER PLANTS

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FOREWORD

Assurance of safety of public and occupational workers, and protection of the environment are important needs to be met in the pursuance of activities for economic and social progress. These activities include the establishment and utilization of nuclear facilities and use of radioactive sources which have to be carried out in accordance with relevant provisions in the Atomic Energy Act 1962 (33 of 62).

Since the inception of nuclear power development in the country, maintenance of high safety standards has been assigned prime importance. Recognising this aspect of nuclear power development Government of India constituted Atomic Energy Regulatory Board (AERB) in November 1983 vide standard order NO. 4772 notified in Gazette of India dated 31.12.1983. AERB has been entrusted with the responsibility of laying down safety standards and frame rules and regulations in respect of regulatory and safety functions envisaged under Atomic Energy Act 1962. In its programme of developing Codes and Safety Guides, AERB has issued Codes of practice covering the following topics:

Safety in Nuclear Power Plant Siting,

Safety in Nuclear Power Plant Design

Safety in Nuclear Power Plant Operation

Quality Assurance for Safety in Nuclear Power Plants

These codes establish the objectives and minimum requirements that shall be fulfilled to provide adequate assurance for safety during operation of nuclear power plants in India.

The Safety Guides are issued to describe and make available methods of implementing specific parts of relevant codes of practice, as acceptable to AERB. Methods and solutions varying from those set out in the Guides may be acceptable if they provide at least comparable assurance that Nuclear Power Plants can be operated without undue risk to the health and safety of the general public and plant personnel.

The Codes and Safety Guides will be subject to revision as and when necessary in light of experience as well as the current state of the art in science and technology. An appendix when included is a part of the document, whereas annexures, foot notes, lists of participants and bibliographies are included only to provide information that might be helpful to the user.

In preparation of the Codes and Guides emphasis is on protection of the site personnel and public from undue radiological hazard. Other aspects such as industrial safety and non radiological protection have not been specifically considered.

However for other aspects not covered in this Guide applicable and acceptable national and international Codes and Standards shall be followed. Industrial safety shall be assured through good engineering practice.

This safety Guide provides guidance for the establishment of a Quality Assurance programme for the commissioning and operation phases of a thermal neutron reactor based power plant in India for assuring safety. While elaborating the requirements stated in the Code of Practice on Quality Assurance for Nuclear Power Plants and in the Code of Practice on Operation of Nuclear Power Plants, it provides necessary information to assist managers in the establishment of the Q.A. programme for commissioning and operation phases. It also provides information on the unique characteristics of these phases that need consideration in the establishment of organisational and other requirements for assuring Safety.

This Safety Guide has been prepared by a consultant, staff of AERB and other professionals. In the preparation, relevant International Atomic Energy Agency (IAEA) documents under the NUSS programme Specifically the Safety Guide on Quality Assurance during Commissioning and Operation of Nuclear Power Plants (50-SG-QA5 Rev 1 of IAEA) has been utilised extensively. It has been reviewed by experts and amended by Advisory Committee before issue. AERB wishes to thank all individuals and organisations who have contributed in the preparation, review and amendment of the Safety Guide. List of persons who have participated in the committee meetings and their organisations is included for information.

(Dr. A. Gopalakrishnan)
Chairman, AERB

CONTENTS

SAFETY GUIDE ON QUALITY ASSURANCE DURING COMMISSIONING AND OPERATION OF NUCLEAR POWER PLANTS

1. INTRODUCTION

1.1 General

1.1.1 This Safety Guide forms part of the Atomic Energy Regulatory Board's (AERB's) programme for establishing Codes, Guides and other standards for assuring safety in the operation of land based stationary nuclear power plants based on thermal reactors (NPPs) in India. It provides guidance on the establishment of the Quality Assurance Programme (QAP) during the commissioning/operation phases. It is recognised that multi-unit sites would have some units under construction and other under commissioning/operation. The units under commissioning/operation shall comply with the requirements of this Guide.

1.1.2 The principles and objectives stated in the Code of Practice on Quality Assurance for Safety in Nuclear Power Plants (AERB/SC/QA)* called hereafter as the Code and in the Code of Practice on Safety in Nuclear Power Plant Operation (AERB/SC/O)* called hereafter as Operation Code form the basis of this Safety Guide.

1.1.3 Safety during commissioning of an NPP depends on proper siting, design and construction. In addition, commissioning of the plant needs to be carried out by competent persons in a co-ordinated and safe manner to ensure that management objectives (Section 4.1 of Operation Code) are met. Safety during operation depends, in addition to the above, on satisfactory performance and alertness of the plant management, other operating personnel and related off-site personnel who are appropriately trained.

1.1.4 Establishment of QAP for these two phases ensures an organized arrangement for monitoring satisfactory performance, for identifying inadequacies and, where possible, incipient failures for timely corrective action.

1.1.5 The latter stages of commissioning are, in effect, the initial operation phase of the plant. Hence, all QA requirements of the operation phase are applicable to the commissioning phase.

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*This refers to the:
AERB/SC/QA, June 1988
AERB/SC/O, September 1989

Factors which require special considerations for the commissioning phase are given in Section 4.5.4 of the Code

1.2 Document Arrangements

1.2.1 The applicable special aspects to be considered in establishing the QAP for commissioning and operation are covered in Section 3. Sections 4 to 7 address specific aspects of QAP during operation. Special considerations applicable to the commissioning stage are covered in Section 8. Section 9 covers record requirements.

1.2.2 The statements in the Code and Operation Code are not repeated for brevity. It is assumed that user would refer to these codes while using this document for the formulation and implementation of the QA programme.

2. DEFINITIONS

The following definitions apply to this Guide and may not necessarily conform to definitions adopted elsewhere for national and international use.

Acceptable Limits

Limits acceptable to AERB for Accident Conditions.

Accident Conditions[1]

Substantial deviations from Operational States which are expected to be infrequent, and which could lead to release of unacceptable quantities of radioactive materials if the relevant engineered safety features did not function as per design intent.

Active Component[2]

A component whose functioning depends on an external input, such as actuation, mechanical movement, or supply of power, and which therefore influences system processes in an active manner (See Passive Component).

Anticipated Operational Occurrences[3]

All operational processes deviating from Normal Operation which are expected to occur once or several times during the operating life of the plant and which in view of appropriate design provisions, do not cause any significant damage to Items Important to Safety nor lead to Accident Conditions (see Operational States).

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1 A substantial deviation may be a major fuel failure, a Loss of Coolant Accident (LOCA) etc. Examples of engineered safety features are : an Emergency Core Cooling System (ECCS), and Containment.

2 Examples of Active Components are pumps, fans, relays and transistors. It is emphasized that this definition is necessarily general in nature as is the corresponding definition of Passive Components. Certain components, such as rupture discs, check valves, safety valves, injectors and some solid-state electronic devices, have characteristics which require special consideration before designation as an Active or Passive Component.

3 Examples of Anticipated Operational Occurrences are loss of normal electric power and faults such as turbine trip, malfunction of individual items of normally running plant, failure to function of individual items of control equipment, loss of power to main coolant pump.

Approval

Formal consent to a proposal.

Applicant

The organization that applies for formal authorisation to perform specified activities related to the Siting, Construction, Commissioning, Operation and Decommissioning of NPP.

Atomic Energy Regulatory Board (AERB)

National authority designated by Government of India, assisted by technical and other advisory bodies, and having the legal authority for conducting the authorization process, for issuing authorisation and thereby for regulating nuclear power plant Siting, Construction, Commissioning, Operation and Decommissioning or specific aspects thereof.

Audit

A documented activity performed to determine by investigation, examination and evaluation of objective evidence, the adequacy of, and adherence to, established procedures, instructions, specifications, codes, standards, administrative or operational programmes and other applicable documents, and the effectiveness of implementation.

Authorization

The granting of written permission by AERB to perform specified activities.

Certified person

A person who has been qualified to hold a certified position.

Certified position

A position which can be held only by persons certified by AERB or a body designated by it.

Commencement of Operation[4]

The beginning of an activity which could lead to critical configuration of the core.

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4 Eg. Fuel loading in case of light water reactors and in case of Pressurised Heavy Water Reactors, heavy water addition with fuel already loaded.

Commissioning

The process during which plant components and systems, having been constructed, are made operational and verified to be in accordance with design assumptions and to have met the performance criteria; it includes both non-nuclear and nuclear tests.

Contractor

An individual or organisation rendering Service (e.g. design, construction, inspection, review, repair) or supplying items.

Competent Authority

A national or state authority, designated or otherwise recognised as such for a specific purpose.

Construction[5]

The process of manufacturing and assembling the components of a NPP, the erection of civil works and structures, the installation of components and equipment, and the performance of associated tests.

Decommissioning[5]

The process by which a NPP is finally taken out of Operation which includes completion of de-fueling of the core and associated activities.

Design Input[6]

Those criteria, parameters, bases or other requirements upon which detailed final design is based.

Design Output[6]

Documents, such as drawings, and specifications, that define technical requirements necessary for manufacture, installation and operation of structures, systems and components.

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5 The terms Siting, Construction, Commissioning, Operation and Decommisioning are used to delineate the five major stages of the authorization process. Several of the stages may coexist; for example, Construction and Commissioning, or Commissioning and Operation.

6 The definitions refer to Quality Assurance activity as discussed in Quality Assurance Code and Guides. Prior specifications means approved specification.

Disposition[6]

An action to determine how a departure from specified requirements is to be handled or settled.

Documentation[6]

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

Emergency Situation

A situation which endangers or threatens to endanger safety of Site personnel, the NPP or the environment and the public.

Examination

An element of Inspection consisting of investigation of materials, components, supplies, or services, to determine conformance with those specified requirements which can be determined by such investigation.

Inspection

Quality Control actions which by means of Examination, observation or measurement determine the conformance of materials, parts, components, systems, structures as well as processes and procedures, with predetermined quality requirements.

Item

A general term covering structures, systems, components, parts or materials.

Items Important to Safety

The items which comprise:

(1) those structures, systems, and components whose malfunction or failure could lead to undue radiation exposure of the Site Personnel or members of the public.[7]

(2) those structures, systems and components which prevent Anticipated Operational Occurrences from leading to Accident Conditions; and,

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7 This includes successive barriers set up against the release of radioactivity from nuclear facilities.

(3) those features which are provided to mitigate the consequences of malfunctions or failure of structures, systems or components.

Non-conformance

A deficiency in characteristics, documentation or procedure which renders the quality of an item unacceptable or indeterminate.

Normal Operation

Operation of a Nuclear Power Plant within specified Operational Limits and Conditions including shut-down, power operation, shutting down, starting up, maintenance, testing and refueling (see Operational States).

Nuclear Power Plant (NPP)

A thermal neutron reactor or reactors together with all structures, systems and components necessary for safety and for the production of power, i.e. heat or electricity.

Objective Evidence[6]

Qualitative or quantitative information, record or statement of fact, pertaining to the quality of an item or service, which is based on observation, measurement or test and which can be verified.

Operating Organization

The organization so designated by Responsible Organisation and authorised by AERB to operate the plant.

Operating Personnel

Those members of Site Personnel who are involved in the operation of the NPP.

Operation[5]

All activities performed to achieve, in a safe manner, the purpose for which the plant was constructed, including maintenance, refueling, In-Service Inspection, Environmental monitoring and other associated activities.

Operation Code

Code of Practice on Safety in Nuclear Power Plant Operation, AERB/SC/O, Sept. 1989 issued by AERB.

Operational Limits and Conditions (OLCs)

A set of rules approved by AERB which set forth parameter limits, the functional capability and the performance levels of the equipment and personnel for safe operation of the NPP.

Operational Records

Documents, such as instrument charts, certificates, log books, computer print-outs and magnetic tapes, made to keep objective history of the NPP operation.

Operational States

The states defined under Normal Operation and Anticipated Operational Occurrences (see Normal Operation and Anticipated Operational Occurrences).

Passive Component[8]

A component which has no moving part, and for example, only experiences a change in pressure, in temperature, or in fluid flow in performing its functions. In addition, certain components, which function with very high reliability based on irreversible action or change, may be assigned to this category (see Active Component).

Physical Separation

(1) Separation by geometry (distance, orientation, etc.), or

(2) Separation by appropriate barriers, or

(3) Separation by a combination thereof.

Plant Management

The members of Site Personnel who have been delegated responsibility and authority by the Responsible Organisation or Operating Organization for directing the Operation of the plant.

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8 Examples of Passive Components are heat exchangers, pipes, vessels, electrical cables, and structures. It is emphasized that this definition is necessarily general in nature as is the corresponding definition of Active Components. Certain components, such as rupture discs, check valves, safety valves, injectors and some solid-state electronic devices, have characteristics which require special consideration before designation as an Active or Passive Components.

Potential

A possibility worthy of further consideration for Safety.

Prescribed Limits

Limits established or accepted by AERB for Operational States.

Qualified person

A person who, having complied with specific requirements and met certain conditions, has been officially designated to discharge specified duties and responsibilities.

Quality[6]

The totality of features and characteristics of a product or service that bear on its ability to satisfy a defined requirement.

Quality Assurance (QA)[6]

Planned and systematic actions necessary to provide adequate confidence that an item or facility will perform satisfactorily in service.

Quality Control[6]

Quality Assurance actions which provide a means to control and measure the characteristics of an item, process or facility in accordance with established requirements.

Records[6]

Documents which furnish objective evidence of Quality of items and activities affecting quality.

Reliability

The probability that a device, system or facility will perform its intended function satisfactorily for a specified time under stated operating conditions.

Repair[6]

The process of restoring a non-conforming item to a condition such that the capability of this item to function reliably and safely is unimpaired, even though that item still may not conform to the original specification.

Responsible Organization (RO)[9]

The organization having overall responsibility for siting, design, construction, commissioning, operation and decommissioning the NPP.

Rework[6]

The process by which a non-conforming item is made to conform to a prior specified requirement by completion, remachining, reassembling or other corrective means.

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.

Safety Limits

Limits upon process variables within which the operation of the NPP has been shown to be safe.

Safety Report

A document provided by the RO to AERB containing information concerning the NPP, its design, accident analysis and provisions to minimize the risk to the public and to the Site Personnel.

Safety Systems

Systems important to Safety, provided to assure, in any condition, the safe shutdown of the reactor and the heat removal from the core, and /or to limit the consequences of Anticipated Operational Occurrences and Accident Conditions (See Anticipated Operational Occurrences and Accident Conditions).

Services

The performance by a supplier of activities such as design, fabrication, inspection, non-destructive examination, repair or installation.

Site

The area containing the NPP, defined by a boundary and under effective control of the Plant Management.

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9 In the present context Nuclear Power Corporation of India Limited (NPCIL) is the Responsible Organisation for Nuclear Power Plants in India.

Site Personnel

All persons working on the site, either permanently or temporarily.

Siting[5]

The process of selecting a suitable Site for a Nuclear Power Plant, including appropriate assessment and definition of the related design bases.

Shift Charge Engineer

A certified person who is available on the site till relieved and is responsible for assuring safe operation.

Specification[6]

A written statement of requirements to be satisfied by a product, a service, a material or a process, indicating the procedure by means of which it may be determined whether the specified requirements are satisfied.

Supplier Evaluation[6]

An appraisal to determine whether or not a management system is capable of producing a product or service of a stated quality, and generating evidence that supports decisions on acceptability.

Surveillance[10]

The act of monitoring or observing to verify whether an Item or activity conforms to specified requirements.

Technical Specification for Operation

A document submitted on behalf of or by the Responsible Organisation covering Operational Limits and Conditions, Surveillance and administrative control requirements for operation of the NPP and approved by AERB.

Testing

The determination or ascertaining of the capability of an item to meet specified requirements by subjecting the item to a set of physical, chemical, environmental or operational conditions.

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10 This includes activities performed to assure that provisions made in the design for safe operation of the NPP continue to exist during the life of the plant.

The Code

Code of Practice on Quality Assurance for Safety in Nuclear Power Plants (AERB/SC/QA), June 1988 issued by AERB.

Verification

The act of reviewing, inspecting, testing, checking, auditing, or otherwise determining and documenting whether items, processes, services or documents conform to specified requirements.

3. QUALITY ASSURANCE PROGRAMME

3.1 The Responsible Organisation (RO) shall establish a Quality Assurance Programmee for the commissioning and operation phases. The programme shall be in conformance with the Code and cover aspects described in Operation Code.

The QA programme shall cover the following functions:

(i) Management functions;
(ii) Performance functions;
(iii) Verification functions;
(iv) Corrective functions

3.2 A Quality Assurance manual shall be prepared for each nuclear power plant. It shall cover all aspects of the programme taking into consideration the requirements intended in the technical specification for operation of the NPP. Where applicable, it shall relate to the requirements of other relevant statutory codes and standards. The manual shall be approved by the authority designated by RO and shall be available in time to enable the intended functions to be performed in an orderly manner. Time and manner of transition from construction to commissioning phase and from commissioning to operation phase shall be identified in the QA manual.

3.3 Contents of the Quality Assurance Manual

1.0 Introduction and Scope

2.0 Policy Statement**

3.0 Management functions (including responsibility for QA programme and its manual, organisation and organisational interfaces).

4.0 Performance functions

5.0 Verification functions

6.0 Corrective functions including non-conformance control.

** Typical Policy Statement should include as a minimum the following elements:
a) Link with RO's QA Manual
b) Framework for safe, reliable and efficient operation
c) Identification of authority of QA in QAP formulation and implementation
d) Review of mechanisms to assure maintenance of safe status
e) Verification function
f) Regulatory interface

7.0 Reports and records

8.0 List of next tier documents and standard formats (List as given in Annexure-III).

3.4 The QA manual shall identify the items or activities to which it applies and, define the responsibilities and authorities of various organisational units and levels both on-site and off-site for implementation and verification.

3.5 The various aspects to which QA requirements apply include the following. However, the level of control for items important to safety shall be in accordance with Section 3.5.4 of the Code.

3.5.1 selection, training, qualification and, as applicable, certification of personnel;

3.5.2 adequacy of and compliance with operational limits and conditions;

3.5.3 availability, adequacy and review status of plans, schedules, procedures, checkoff sheets, etc. for operations, maintenance and other services;

3.5.4 surveillance activities including in-service inspection;

3.5.5 maintenance activities;

3.5.6 radiological protection and industrial safety;

3.5.7 management of radio-active materials including fresh and irradiated fuel, special irradiated assemblies and radio-active wastes;

3.5.8 reactor core management;

3.5.9 fuel handling;

3.5.10 review of plant performance;

3.5.11 emergency preparedness including management of situations arising from external events both natural and man-made;

3.5.12 environmental monitoring;

3.5.13 security including access control;

3.5.14 review of operating experience and new information and actions based thereon;

3.5.15 modification to plant and procedures;

3.5.16 procurement of items and services.

3.6 The head of plant management shall be responsible for ensuring that all tasks assigned to the on-site organisation are carried out in a timely manner. He is also responsible for ensuring that all on-site activities conducted do not jeopardise safety. He shall have requisite authority for effective discharge of his responsibilities for ensuring safety.

3.7 The QA manual shall be formally reviewed once in three years or more frequently, if necessary as required by Section 3.6.1 of the Code.

4. ORGANISATION

4.1 Establishment of the organisational structure specially the site organisation shall be in accordance with the requirements stated in Sections 5 and 6 of Operation Code and take account of the required special considerations (refer Section 4.3).

4.2 Aspects that need consideration in developing organisational arrangements include:

(i) plant control responsibilities and authorities;
(ii) authorities and responsibilities of the head of plant management and other key site personnel;
(iii) authorities and responsibilities of corporate office personnel including transfer of responsibility to or from the plant management;
(iv) manpower training, qualification and certification;
(v) coping with emergency situations; and,
(vi) technical support to shift charge engineer to cope with unusual situations.

4.3 Important considerations in operations phase for any activity are:

(i) the prediction of results,
(ii) the actual performance, and
(iii) comparison of results with predictions and acceptance criteria.

If the persons who predict the results are independent of the performer, the performer acts as a verifier. It is important to establish a system of checks and balances, well documented, wherein each of the constituent wings that has responsibility for an item or aspect, monitors the work of others as a part of discharge of own performance functions. Formal verification activities are, however, necessary as they contribute towards continual improvement of the above system but in no case it can replace the built-in verification system of checks and balances.

Three examples illustrating the special aspects of QA during operation are covered in the foot note.

4.4 Quality Assurance Organisation

4.4.1 On site Q.A. team shall report directly to the head of plant management and will be led by a person who is sufficiently independent of cost and schedule considerations. He shall report on the effectiveness of quality management to the head of plant management and, to the Q.A. department of the corporate office.

On site QA team is responsible for verifying state of health of Items Important to Safety and review of activities (both direct operations and supporting) for purpose of process control, product acceptance and to ensure that activities conform to specifications.

4.4.2 Off-site Q.A. team is responsible for the review of reports of the on-site organisation, audit and verification of quality on random basis. On-site personnel may be co-opted to the extent considered necessary.

4.4.3 Level of authority and independence from cost and schedule consideration shall be in accordance with Section 3 of the Code.

4.4.4 Members of the Q.A. team shall be aware of the special requirements to be met for assuring safety during the operation phase and shall be familiar with verification functions.

(i) The Reactor Physicist, Instrument Engineer and Shift Charge Engineer have a direct concern for operability of instrumentation and controls related to neutron flux and thermal power in the core both local and global. Each of them should have specific responsibilities in assuring operability of some or all the instrumentation and controls.

(ii) All the three maintenance disciplines (Mechanical, Electrical and Instrumentation), Shift Operations, Inspection/Surveillance Engineers and Technical Services have direct concern regarding operability of Safety related machinery and equipment, and should have assigned roles in maintaining the desired reliability.

(iii) Work methods including preparatory activities before the main activity is undertaken, have a major role in controlling radiation exposure of skilled occupational workers and in the achievement of quality. Apart from radiation protection personnel and those with responsibility to execute the main activity, other disciplines/work units including chemistry and decontamination have a major role to play in planning and implementation.

4.4.5 Training of personnel who are assigned to assess the effectiveness of QA programme should cover problem solving techniques such as flow charting, histograms, pareto analysis, cause/effect analysis techniques as relevant to them, and should use these techniques in the evaluation of the programme.

4.4.6 Persons assigned responsibility for independent review and other verification functions shall collectively represent expertise and experience as a minimum in the following areas:

(i) Nuclear Power Plant Operation;
(ii) Nuclear Engineering and Reactor Physics;
(iii) Chemistry & radio-chemistry;
(iv) Metallurgy;
(v) Non-destructive Testing;
(vi) Instrumentation and Control;
(vii) Mechanical Engineering;
(viii) Electrical Engineering;
(ix) Radiation Protection;
(x) Inservice Inspection and Quality Assurance Practices;
(xi) Emergency Planning and Management;
(xii) Manpower training, qualification, certification and man management;
(xiii) Fields of unique relevance to a plant, eg. heavy water management in case of PHWRs;
(xiv) Effluent management;
(xv) Aging of components and systems;
(xvi) Reliability analysis; and,
(xvii) Fire protection and mitigation.

5. PROCEDURES

Any activity could be performed in different ways and may also involve more than one person and sometimes more than one crew.

5.1 It is, hence, necessary to regulate, the methods adopted by different individuals responsible for the same function. Hence, it is necessary that all activities for normal operation, anticipated operational occurrences and for coping with accident conditions are conducted in accordance with standard procedures, both administrative and technical.

However, as off-normal situations cannot be pre-defined in complete detail, response to an actual situation (initiated by an event or events) can at best be spot decided. This decision can be based on a combination of a set of documented responses. The success of such responses depends on the plant configuration as identified by the operating personnel. These procedures shall be written in detail and in an unambiguous manner.

5.2 Procedures are normally directed towards administrative or technical aspects. Procedures for coping with abnormal situations (particularly accident conditions and emergencies), should have adequate detail to enable a trained person to respond in a timely manner.

5.3 Measures shall be established for the preparation, review, approval and issue of procedures and their updating. All procedures shall be reviewed at specified intervals not exceeding five years for updating. In addition, special reviews for updating may be undertaken based on modifications (see section 16.0 of Operation Code), operating experience and new information.

5.4 Procedures and instructions on administrative aspects should cover the following:

(i) authorities and responsibilities for operation including those assigned to the person with ultimate responsibility for safety (normally the head of the Plant Management);
(ii) authorities and responsibilities of the shift charge engineer and other key operating personnel;
(iii) security and visitor control (see Section 12.0 of Operation Code)
(iv) control of access to control room and other critical areas;
(v) equipment control (locking, tagging etc.) including removal from service and return to service;
(vi) procedure preparation, review, approval and compliance;
(vii) authority and responsibility for coping with situations for which procedures are not available;
(viii) schedule for housekeeping, routine contamination monitoring and control;

(ix) chronological, summary and event logs in control room and other manned stations, and data logs – generation, reviews, record and retention;
(x) schedules for monitoring including assay of grab samples, derivation of plant condition from monitored data, instrument check, functional tests and calibrations;
(xi) schedules and other administrative aspects of in-service inspection;
(xii) shift and relief turn over taking account of part way progress of activities and off-normal situations including emergency situations;
(xiii) shift complement – minimum requirements, qualification, certification and re-training requirements and overtime limitation;
(xiv) procedures for effecting bypasses or jumpers including reporting, and normalisation requirements;
(xv) review requirement regarding routine and special reports and corrective action;
(xvi) dissemination of operating experience within the plants and elsewhere and periodic review of required actions;
(xvii) documentation, their preservation and ready availability;
(xviii) intergroup and intragroup co-ordination;
(xix) procedures for issue of work orders and work permits;
(xx) industrial safety aspects;
(xxi) reporting of off-normal situations including those covered by the Technical Specifications for operation and other statutory requirements;
(xxii) plant procedures to assure preparedness for coping with fires, radiological emergencies and personnel emergencies;
(xxiii) provision for technical and other support during emergencies; and,
(xxiv) transfer of charge of Site Emergency Director and other duties during an emergency.

5.5 Technical procedures shall cover the following;

(i) overall plant operation within the operational limits and conditions, and other requirements for compliance with design intent, manufacturer's instructions and good engineering practice;
(ii) operation of systems and equipment;
(iii) maintenance;
(iv) surveillance testing including inservice inspection;
(v) fuel and core management, and handling of fuel and other core components;
(vi) chemistry and radio-chemistry control;
(vii) radioactive effluents and other waste management;
(viii) emergencies and other significant events; and,
(ix) special material control – e.g. fuel and heavy water.

5.6 Aspects to be considered in the development of a technical procedure shall include the following:

(i) effect if any, on other systems and components;
(ii) radiation protection requirements;
(iii) non-radiological hazards and precautions;
(iv) personnel and procedure qualification;
(v) special training including rehearsal requirements;
(vi) identification of acceptance criteria including the applicable statutory codes and standards; and
(vii) possible sources of human error including those arising from instrument misbehavior.

5.7 Each operating procedure shall include:

(i) title – A title descriptive of the activity, and the system or unit to which the procedure or instruction applies;
(ii) references – References, as necessary for items such as drawings and other design documents, operational limits and conditions, and relevant operating and maintenance procedures;
(iii) general information providing information on key parameters, setting and interlocks;
(iv) purpose;
(v) pre-requisites – such as technical, administrative and manpower;
(vi) initial conditions of the system/systems;
(vii) step by step procedures covering actions and observations; and stagewise assessment before proceeding to the next stage;
(viii) checklists – When complex procedures or instructions are involved, checklists may be included as part of the procedure or instruction, or may be attached as appendices;
(ix) final status;
(x) acceptance criteria including those for stage checks; and,
(xi) anticipated hazards and safety precautions.

5.8.1 Temporary procedures and instructions may be necessary to cover situations not covered by standard procedures. Factors necessitating the use of such procedures include;

(i) special operations during testing, re-fuelling, maintenance and modifications; and,
(ii) effect of temporary de-rating specially for compliance with the letter and spirit of operational limits and conditions.

5.8.2 For conditions not covered by approved detailed procedures operating personnel shall be given written instructions to perform a specified task.

5.8.3 All temporary procedures and instructions shall specify the period of time and the specific plant and specified activity configuration for which they only may be used. Completion of the activity shall be reported and reviewed at appropriate level.

5.9 Plant management shall define the requirements for compliance with administrative and technical procedures and, monitor compliance. Activities or stages requiring checklists and verification, and those to be committed to memory shall be stated.

Checklist requirement should be based on complexity and frequency of the activity. Requirement for commitment to memory depends on response time considerations and usually involve abnormal situations. The tasks shall be identified for which the operator shall have committed the procedural steps to memory.

5.10 Copies of all procedures shall be available for training of operating personnel and at key locations including the control room. Relevant procedures shall be available at duty stations.

6. ACTIVITIES/PROCESSES TO BE CONTROLLED

The requirements stated in section 4 of the Code shall be adhered to. Aspects requiring special emphasis during operation are only discussed.

6.1 Document Control (see Section 4.1 of the Code)

6.1.1 Document change control and the consequent release and distribution deserve special attention. Any lapse in assuring prompt replacement of obsolete documents at the control room and other duty stations as also in assuring awareness of the operating personnel of the approved changes can result in significant information gap with potential adverse effect.

6.1.2 Documents to be available at the control room and other control locations should be listed by plant management and availability verified periodically by the QA team.

6.2 Communication

Adequate level of communication of information between the following shall be achieved and the requirement therefore will be covered in the relevant plant procedures.

(i) personnel within an operational shift;
(ii) amongst operational shifts (i.e. between shift crews);
(iii) between operational shifts and management;
(iv) between operational shifts and services including maintenance;
(v) amongst different wings of management;
(vi) plant management and off site organisations such as Corporate Office, Regulatory Body, etc.
(vii) operating personnel and other on-site groups, and
(viii) amongst participating agencies including site personnel during an emergency situation.

Transmission of information will be in accordance with procedures appropriate to the activity and, where possible, through standard formats such as work permits, work and test permits, radiological work permits, deficiency reports, radiation survey reports, order to operate (OTO), chronological logs, and summary logs.

6.3 Operations Control (See Section 4.5.5 of the Code)

6.3.1 Status of equipment.

Release of items (structures, systems and components) for maintenance, repair, testing, modification or any other purpose shall be controlled and documented.

Designated operating personnel (by post) shall assess the consequences of removing the item from service; such assessment shall include compliance with the operational limits and conditions (Section 7 of Operation Code) and verification requirement. Appropriate control measures such as locking and tagging shall be adopted for protection of personnel and equipment during maintenance and testing. Where tags are used for display on panels, care shall be taken (by design and work practice) that ability to monitor instrument, indicating lights and permanent tags remains unimpaired. Communication requirements shall include timely and complete availability of information to the shift charge engineer and other relevant shift personnel on the status of the released item.

On completion of the job on the released item, aspects to be considered for return to service shall also include pre-requisite check out on the item, the related instrumentation and control, controlled removal of tags and locks, testing and verification.

Release of item from service and return to service shall be controlled by designated shift operations personnel. The activity shall be reported in the chronological log of the duty station and, where applicable, in other documents prescribed by the plant management.

Requirement for verification shall be based on the importance of the item to safety, (see Section 3.5.4 of the Code specially sub-sections ‘a’ and ‘b’) and, in addition radiation exposure if level of importance is acceptably low. Verification shall be carried out by a person qualified to perform the task being verified but had not participated in the performance. Temporary modifications such as temporary lines, electrical jumpers and changes to trip settings shall be authorised by designated personnel only and controlled.

So long as correct configuration can be established by it, testing is an acceptable substitute for verification.

6.3.2 Maintenance Control

Maintenance programme shall be developed and implemented. The programme shall specify the frequency and type of maintenance to be performed on each item. Procedures for each type of maintenance for an item should be available and complied with. Procedural instructions obtained from manufacturers or those prepared by the operating organisation are acceptable. Use of check sheets in which observations, qualitative or quantitative, are recorded together with desired values and acceptance criteria should be adopted to enable failure or trend analysis and investigation of malfunctions and corrective action thereof. These could be design changes and modification of operating procedure, maintenance procedure and inspection/test methods and frequency.

An aspect of maintenance important to nuclear plants is radiation dose collation to identify activities requiring attention for reduction of integrated dose to personnel (person-Sv per year). Maintenance procedures and schedules shall be reviewed once in three years or more often if necessary, for maintaining the desired reliability both regarding availability and capacity of the item.

6.3.3 Modification and Replacement

All engineering activities for modification and replacement shall be carried out in accordance with applicable codes and standards for design, procurement, construction and commissioning. (see also Sections 4.1, 4.2, 4.3, 4.4, 4.5.1, 4.5.2, 4.5.3 and 4.5.4 of the Code).

6.3.4 Housekeeping

Following aspects as applicable should be attended in a planned way for housekeeping:

(i) Cleanliness of the area: Area should be free from oil, dust, water, loose parts, etc.
(ii) Lighting in the area: Lighting should be adequate for operation and maintenance.
(iii) Drainage points are clean and functional.
(iv) Heavy water recovery equipment is available in the areas having potential for Heavy Water spillage.
(v) Radiation level sign boards are in position giving up-to-date status.
(vi) Caution boards are displayed wherever required.
(vii) Area identification boards are displayed with clear markings.
(viii) Equipment identification tags are in position with clear markings.
(ix) Surfaces of pipes, ducts, cables, cable trays, equipment, floors, walls, ceilings, etc. are clean.
(x) Painting of all surfaces is in good condition.
(xi) Rubber areas, change areas, rubber and plastic apparels are arranged properly.
(xii) Mask air lines, fire hydrants, etc. are functional.
(xiii) Smoke alarms/fire alarms are functional
(xiv) Telephone and maintenance jacks are functional.
(xv) Enclosures and doors are kept in desired positions.
(xvi) Ventilation fans/exhaust fans are working.
(xvii) Equipments/pipe/duct/cable tray supports are intact.
(xviii) Dismantled equipment/tools/cylinders etc. are not kept in the area.

6.4 Inspection, Surveillance and Testing

These activities shall be performed to be in conformity with Section 9.0 (Maintenance, Inspection and Testing) and Section 15 (Commissioning) of Operation Code and, Section 4.4 (Control of Items) and 5.6 (Calibration and Control of Measuring and Test Equipment) of the Code.

6.4.1 Scheduling

Schedules shall be available and complied with to ensure that frequency of testing and inspection is commensurate with the importance of the Item to safety. A master schedule covering an adequate period (The interval between two successive surveillance tests of lowest frequency, e.g. containment leak rate test may be appropriate) reflecting the required and actual status of surveillance activities at any time, is recommended. These should indicate the date of latest test and the dates between which it shall be repeated. This would enable outage planning for surveillance testing or maximise utilisation of outages for other reasons. Requirements for continued plant operation and re-scheduling of tests/inspections not carried out in accordance with original schedules shall be stated. Such re-scheduling should not be considered if violation of technical specification for operation results from such action.

6.4.2 Receiving Inspection

Measures shall be established to inspect items on receipt as per the requirements of the procurement document. These include one or more of the following;

(i) identify, inspect and, if required, test the items;
(ii) check the objective evidence provided by the supplier to confirm that the item meets the requirements of the codes, standards, specifications and drawings stated in the procurement document;
(iii) verify that the documents provided by the supplier have been reviewed to ensure that technical requirements are met; and,
(iv) where applicable, segregate the conforming and non-conforming items to prevent inadvertent use of non-conforming item,
(v) Complete disposition actions of non-conformance.

6.4.3 Inspection of Activities

Activities to be inspected shall include;

(i) plant operation;
(ii) preventive maintenance;
(iii) thermal and nuclear performance vis-à-vis predictions and other aspects of plant performance;

(iv) radiation protection, chemistry and radio chemistry;
(v) fuel handling including shipping off-site and radio-active waste management;
(vi) in-service inspection;
(vii) functional and other tests (see Section 7.7 of Operation Code); and,
(viii) emergency preparedness including emergency exercises.
(ix) trend analysis of data from seismic arrays, environmental monitoring, on-site & off-site and trend monitoring of plant parameters.

6.4.4 Testing

To ensure that the plant status and performance meets the acceptance criteria and for early identification of the need to repair, replace or modify the necessary hardware, testing carried out shall include the following;

(i) tests to demonstrate capability where such verification is not possible prior to operation eg. heat transfer capability of heat exchangers and operation at specified parameters of pumps. This enables verification of conformance to safety requirements and to establish baseline data where precise prediction is impractical;
(ii) surveillance tests such as monitoring, instrument check, functional testing and calibration including, where applicable, response time verification;
(iii) tests during operation phase to verify compliance with requirements subsequent to maintenance and modification; and,
(iv) tests on installed plant required by competent authorities.

6.4.5 Procedures and Reports for Testing and Inspection

Procedures in suitable format (see section 5.7) shall be available and results documented in standard formats. Procedures shall identify witnessing requirements and, where applicable, hold points. Criteria to be met for proceeding beyond the hold point shall be stated.

Test and inspection results shall be documented and evaluated by designated persons to verify compliance with requirements. Evaluation reports thereon shall include a record of data, as found status, corrective actions taken if any, final status and identification of persons who conducted the test or inspection and those who evaluated it.

6.4.6 Calibration and Control of measuring and test equipments

This shall comply with the requirements of Section 5.6 of the Code. Testing and measuring equipment shall be of the proper type, range and precision and be in proper condition to establish conformance to specified requirements.

Measures to meet the above requirements apply to equipment including the following;

(i) instrumentation for items important to safety;
(ii) instruments and other equipments used for inspection, examination and tests including those permanently installed; and,
(iii) portable and laboratory standards used for calibration.

Calibration procedures and frequency shall be defined taking account of the type of instrument, its stability, environmental conditions, reliability characteristics and accuracy requirements. Frequency may be modified based on experience. Procedures shall state the reference devices or standards used in calibration such as test gauges, dead weight testers, milli-volt meters and penetrameters.

When results of calibration indicate drifts beyond acceptance criteria, previous measurements made shall be evaluated and acceptance of test results re-assessed.

Calibration records for each equipment shall be maintained. All equipment should be marked to indicate the calibration status and the due date of next calibration.

6.5 Non-Conformance Control and Corrective Actions

Measures shall be established to assure compliance with Section 6 of the Code. Aspects that need special consideration are:

(i) non-compliance with technical specifications for operation;
(ii) non-compliance with the Manual for Radiation Protection issued by the SARCOP;
(iii) non-compliance with the Atomic Energy Factories Rules;
(iv) deficiencies in programmes identified during reviews and audits including review of experience in other plants; and,
(v) Safety related unusual occurrences.

All non-conformance reports shall be adequately detailed to enable a proper review, evaluation and disposition. Individuals and organisations including, where relevant, design organisation for review of non-conformance and implementation of corrective action shall be identified.

7. VERIFICATION

7.1 General

Unless otherwise specified, verification of activities performed may be carried out by another member of the same organisational wing including the supervisor who had not participated in the activity. It shall, however, be ensured that the verifier is qualified to perform the task.

Because of the importance of the activity to safety, verification by a member of a different organisational wing among the operating personnel or by a person independent of the plant management may be required for specific activities.

Items to be verified include those covered in Section 6.4.3 and during commissioning, Section 8.13.3.

7.2 Assessment

7.2.1 Indicators for assessing the effectiveness of the QA Programme

a) Inputs to measure effectiveness of the programme are the qualitative and quantitative indicators available in the form of normal plant data both on plant performance and activities of personnel. The data is normally collected by operating personnel, health physicists and QA personnel.

b) Qalitative Indicators:

Inadequacies observed in the performance of personnel and plant, unusual occurrences and non-conformances which are not large in number for reliable quantitative index, are examples of such indicators. The inputs are the result of review or audit of reports on unusual occurrences, corrective actions, in-service inspections and qualification/requalification of personnel.

c) Quantitative Indicators:

These are numerical results of trend and other analyses on the performance of items. Measured data during operation or testing are the inputs for the analyses.

Aspects to which these apply include;

(i) predictive maintenance data for machinery;
(ii) hydraulic, thermal hydraulic, chemical and radio-chemical performance of systems; and,
(iii) collective dose to personnel in the performance of standardised activities.

A typical list of possible indicators adopted in some countries is given in Annexure-I.

The results of initial reviews [see (b) & (c) above] should be evaluated to identify root cause for deficiencies, if not already brought out.

7.2.2 The effectiveness of plant operation shall be assessed by ongoing review of the significant factors which indicate the state of health of the plant. The assessment should cover the following:

(i) significant operating abnormalities or deviations from expected plant performance;
(ii) changes to operating procedures, equipment, equipment tests or experiments;
(iii) operating experience and characteristics;
(iv) equipment repair, adjustment and replacement trends;
(v) actions taken to correct or mitigate abnormal occurrences;
(vi) unanticipated design or operating deficiencies; and,
(vii) Unexpected material and equipment failures, unnoticed construction deficiencies.

Trend analysis shall also be conducted on results of non-conformance reports, routine inspection and verification results, and the findings from the in-service inspection and audit programmes.

7.3 Audits

7.3.1 A comprehensive system of planned and documented internal and external audits shall be established to verify the implementation and effectiveness of the Quality Assurance Programme and shall be consistent with the requirements stated in Section 5.8 of the Code.

7.3.2 Audits of selected aspects shall be performed with a frequency related to their safety significance. Frequency of audit of all aspects important to safety functions should not be more than two years.

Audit should be performed of the following elements at greater frequencies;

(i) the results of actions taken to correct deficiencies that affect nuclear safety and occur in plant equipment, structures, systems, or method of operation;
(ii) the conformance of plant operation to provisions contained within the operational limits and conditions and other applicable authorisation conditions, and,
(iii) the activities, training and qualifications of the plant staff.

7.3.3 Audits shall include, as a minimum, verification of compliance with and effectiveness of implementation of: internal rules, procedures (e.g. procedures for operation, procurement, maintenance, modification, refuelling, surveillance, test, security, radiation exposure control, and the emergency plan), programmes for training and retraining, qualification and activities of operating personnel, corrective actions taken following abnormal occurrences and, record keeping.

7.3.4 The on-site QA team shall carry out the above audit functions.

7.3.5 In addition to its other functions (See 4.4.2), the off-site QA team shall report on the effectiveness of the QA programme by means of external audit including verification of implementation of corrective actions.

7.4 Reviews by Plant Management

In order to keep abreast of general plant conditions and to verify that the day to day operating activities are conducted safely and in accordance with applicable administrative controls, the plant management shall ensure that the normal duties of plant supervisory personnel include timely and continuing monitoring of operating activities. This monitoring is considered to be an integral part of the routine supervisory function and is important to the safety of plant operation.

The plant management shall perform formal reviews periodically and as the situation demands to evaluate plant operation and documentation, to examine deficiencies, to evaluate corrective actions and to plan future activities. The important elements of the reviews shall be documented.

7.5 Independent review

A system of independent review shall be established by the responsible organisation. This shall use appropriately qualified personnel not directly involved in the day to day operation of the plant to review important activities and changes during operation and to detect trends which might not be apparent to a day to day observer. These personnel shall have access to all information necessary to perform the review.

Items subject to this independent review should include:

(i) significant changes to procedures;
(ii) proposed plant modifications which involve:
- changes to operational limits and conditions
- changes to the previously approved design intent; and,
- an unreviewed safety question;
(iii) reports of abnormal occurrences and significant equipment failures;
(iv) audit reports; and,
(v) any other matter involving safe operation of the nuclear power plant which an independent reviewer deems appropriate for consideration, such as feed back from other nuclear power plants or which is referred to the independent reviewers by the operating organization or other organizational units.

8. COMMISSIONING

8.1 Commissioning of a nuclear power plant is performed to ensure that the plant is capable of achieving the design objectives, meeting the safety requirements and that the operating personnel including the plant management can discharge their functions. Aspects to be considered are covered in Section 4.5.4 of the Code and Section 15 of Operation Code. Sub-sections 4.5.4.3 and 4.5.4.4 of the Code deserve special attention. During this phase of commissioning (which could be generally a light water commissioning phase) performance of all sub-systems, their interaction with other systems shall be ensured to meet the design requirement.

8.2 Quality Assurance requirements for the Operation phase of the plant are applicable during commissioning. Special considerations arise due to the following:

8.2.1 In the absence of formal arrangements and proper attitudes, the simultaneous conduct of construction, commissioning and operation activities could result in ambiguity regarding the agency having primary control and responsibility for individual areas or items.

8.2.2 For the same level of training, procedural arrangements, and personnel and management attitudes, the effort required to maintain the same level of communication amongst different disciplines in the commissioning/operating groups as also between these personnel and the other groups such as construction is significantly more.

8.2.3 The familiarity with the specific installed equipment and layout is an important aspect of overall competency of operating personnel. Earlier walk through, class work, simulator training and earlier experience elsewhere do not substitute for actual work performance. The entire team undergoes the finishing stages of the familiarization process during commissioning.

8.2.4 Even in the case of a plant of standard design using proven equipment, initial cleaning, acceptance testing and performance testing at component and systems level should be as thorough as for a new design for assuring satisfactory performance of the overall plant. This enables correction of non-conformances before constraints make corrective actions difficult and costly because of safety and other requirements applicable to the operation phase. Such corrective action is also applicable to operation, maintenance and testing procedures, and aspects of manpower training specific to the individual plant.

Interface with other systems should be checked and interconnected systems such as secondary side of heat exchangers, set point of controllers, logic wiring of entire control loop etc. should be commissioned completely. Integrated performance of such systems should be adequately demonstrated. Effect of

each system/component on adjacent system from the point of view of spread of fire and transmission of failure (missile effect or whip effect) should also be checked thoroughly.

8.2.5 Large number of field changes both procedural and, systems and components in a short period is a characteristic feature of the commissioning phase.

8.2.6 Subsequent sections cover requirements and considerations supplementary to those covered in Sections 4 to 7 of this Guide.

8.3 Commissioning Plan

An adequately detailed overall plan shall be developed early in the project phase to cover the following:

(i) organisational interfaces on and off the site defining areas of primary responsibility;
(ii) a master network diagram (PERT chart) defining inter-system interfaces for commissioning and test sequence diagrams for individual systems and, where appropriate, components;
(iii) systems cum skills training of commissioning and operating personnel including familiarisation with the plant;
(iv) development of standard formats for testing similar items for their use in operating and commissioning procedures;
(v) procedures for the Operation phase (see Sections 5.3 to 5.8);
(vi) procedures for commissioning with maximised use of procedures for the operation phase so that these procedures can be validated and non-conformance corrected early;
(vii) availability of design basis, description and analysis reports, safety reports, identification of review requirements, review levels and hold points including, where applicable, review and approval by AERB;
(viii) qualification and, for certified positions, certification of personnel;
(ix) submission of proposals to AERB and assurance of compliance with their requirements; and,
(x) Pre-service inspection of safety related items to establish base line data for in-service inspections.
(xi) Commissioning review of items for compliance with design intent (See Section 8.12)

An important aspect to be considered is the timely flow of information from designers, from manufacturers such as instruction manuals and catalogues and from others. For the commissioning group to perform its functions satisfactorily, complete information on an item should be available before site work on construction of the item or equivalent such as panel wiring of an instrument panel by manufacturer, starts.

8.4 Organisation

8.4.1 The Operating Organisation shall be the overall controlling and co-ordinating authority for over-seeing the satisfactory completion of all commissioning work and certify that results of commissioning tests meet the design intent.

An individual with requisite authority shall be identified as responsible for controlling and co-ordinating the commissioning activities including the items covered under Section 8.3.

At a Nuclear Power Plant Site, it is envisaged that some units are under commissioning and/or operation and other units are under construction. The Operating Organisation, shall be independently responsible for the units under commissioning or operation; the Chief of operation (Chief-Superintendent) at site shall be responsible only to the Directorate of Operations at NPC Head Quarters.

8.4.2 Procedures shall be established for the constitution of the group with overall responsibility for execution of the commissioning activities normally called the commissioning group. It may consist of many teams each with responsibility to carry out specific commissioning activities and operate the necessary components and systems. Persons delegated to authorise the work, document the work including observations and prepare, review and approve reports shall be identified.

8.4.3 Verification of satisfactory implementation and other Q.A. activities shall be carried out by persons not directly responsible for commissioning activities and shall be identified.

8.4.4 Where organisational interfaces are involved, responsibilities of individual organisations shall be stated without ambiguity in defining primary responsibility. Procedures for identification, review, approval, release, distribution and revision of documents that cross organisational boundaries, shall be established.

8.5 Transfer of responsibilities

Measures shall be established for the documented transfer of components and systems and the related records from the construction group to the commissioning group and for indicating the change of status of such components and systems. Commissioning personnel shall review the documentation provided by the constructor and any deficiencies should be identified and resolved. When it has been decided that the transfer can be accomplished, the components and systems shall be jointly checked by representatives of the construction and commissioning groups and the turnover records signed to indicate the formal transfer of responsibilities.

Similarly, a documented transfer of components and systems and related records from the commissioning group to the operating group shall be undertaken. After satisfactory completion of the commissioning programme, a documented transfer of the whole plant shall be undertaken. The operating group shall satisfy itself that the systems transferred comply with specified design, performance and safety requirements, and shall formally accept responsibility for the transferred components, systems and related records.

To satisfy itself that the components and systems are ready for transfer, the operating group should:

(i) check all components and systems for: proper identification, completion of commissioning tests and inspections, cleanliness, lubrication, positioning of switches and valves, calibration of instruments, proper status of safety devices, etc.;
(ii) verify that all required commissioning documentation has been completed;
(iii) verify that all deficiencies have been resolved including, where applicable, adequacy of arrangements for correcting balance deficiencies; and,
(iv) Verify that the plant documentation including drawings reflect the as built and commissioning status.

8.6 Document Control

Need for modifications on a large scale and multiple organisational interfaces are characteristic features of the commissioning phase. Special arrangements are necessary to enable timely availability of documents, withdrawal of obsolete documents and up-to-date distribution lists.

8.7 Modification Control

Field changes are carried out to provide temporary facilities for commissioning. Modifications arising from commissioning experience may be carried out before a complete review. It is therefore necessary, as a minimum, that both field changes and modifications are reviewed by designated design and operation groups in a timely manner and corrective action, if any, is implemented before concern for safety could arise. The review group shall have adequate access to the background information and have an understanding of the requirements and intent of the design.

Arrangements established for the above purpose shall ensure that ‘hold points’ are identified for review and, if any, corrective actions arising from modifications including normalising field changes.

8.8 Status of Operating equipment

As construction, commissioning and operating activities could be in progress at the same time, arrangements made shall enable effective discharge of their responsibilities by the various groups particularly effective control by the group assigned the primary responsibility.

Administrative procedures applicable during the Operation phase for release of equipment (see Section 6.3.1.) and return to service after maintenance, repair, modification or testing shall be implemented even as transfer of responsibility of the relevant items from construction to commissioning takes place.

A major aspect requiring special attention is the use of jumpers, bypasses, mechanical blocking of devices and trip settings different from those specified for normal operation many of which would be inescapable for the current state of plant but undesirable (may be, unacceptable) for normal operation. Objective shall be to ensure that specified configuration is established in a timely manner. In this context, it may be noted that non-standard mode of operation of any major safety related item should not be resorted to without formal technical evaluation by the design organisation and is approved by appropriate authority.

More conservative approach than for normal operation is necessary while establishing requirement for independent verification, since familiarisation may not be intimate during the early phases of commissioning. So long as correct configuration can be established by it, testing is an acceptable substitute for physical verification and is specially recommended where radiation exposure could be significant during the Operation phase.

8.9 Maintenance Control

In addition to aspects covered in section 6.3.2, consideration shall be given to preserve quality of items in storage and those installed but idle. Methods include periodic operation at rated conditions or by hand movement, and humidity, temperature and dust control. (Refer to Section 4.4.2 of the Code)

Measures shall be established to:

(i) develop the maintenance programme and procedures;

(ii) establish the shops and other facilities for testing, inspection, maintenance, repair and replacement including facilities for handling radio-active/contaminated materials;

(iii) establish manpower training including, as relevant, hands-on training in manufacturer's works or through participation in construction; and,

(iv) review plant layout and other features by persons with requisite experience in maintenance and in service inspection.

8.10 Calibration and control of measuring and test equipment

Apart from requirements for normal operation, additional instrumentation may be required to enable testing of systems particularly, plant response to planned simulation of transients and failures. The requirements stated in Section 6.4.6 are applicable. In addition, calibration including response time verification may be required just prior to performance of certain tests and should be taken into account in developing the test procedures and their implementation.

8.11 Housekeeping and Cleanliness Control

System cleaning procedures and temporary modifications thereof shall ensure that cleanliness standards of systems are reached before such need arises for assuring safety without potential for damage to or degradation of equipment.

Work schedules for housekeeping and contamination control (see Section 6.3.4.) shall be established early enough so that relevant requirements for radiation protection can be met before the need for the same arises.

8.12 Commissioning Control

Commissioning procedures, commissioning requirements, instructions, work plans and check lists shall be prepared, reviewed and approved by designated individuals before implementation. These will require the results to be recorded, evaluations to be carried out and state the acceptance criteria, whether qualitative or quantitative, as also the anticipated results.

In the preparation of commissioning procedures, consideration shall be given to the aspects covered in Section 5.6 and 5.7 and, to maximise the utilisation of the technical procedures for the operation phase. Special considerations include the following:

(i) intent of the procedure or purpose of test;
(ii) pre-test calibrations, if any;
(iii) deviation from standard configuration with basis where applicable;
(iv) special instrumentation requirement; and,
(v) manpower requirement including the identity of person(s) authorised to direct or witness performance.
(vi) Review of systems design with emphasis on interlock requirements, interfaces, their adequacy and suitability of mechanism by which they are achieved.

Personnel reviewing the procedures shall have adequate understanding of the requirements of the design and intent of the system/component being commissioned. Procedures requiring review by the design organisation shall be identified and the result of such review be incorporated in the procedures appropriately.

Changes to commissioning procedures and instructions shall be subject to the same controls as the original procedures.

8.13 Inspection and Verification

8.13.1 Measures shall be established to verify that;

(i) commissioning plans are adequate;
(ii) procedures comply with the requirements of the plan, design intent, manufacturer's literature and good engineering practice;
(iii) implementation is in accordance with the plan and procedures;
(iv) results are evaluated, and non-conformances dealt with properly;
(v) stage and other reviews are carried out properly by designated persons; and,
(vi) hold point requirements are met before proceeding to the next stage.

8.13.2 Apart from requirements applicable during the operation phase (see Section 6.4), aspects to be covered include inspection and surveillance of commissioning tests, control of procedures, reports and other records and commissioning status.

8.13.3 Inspection and Surveillance of commissioning tests

The verification shall confirm that the acceptance criteria specified in the relevant approved documents are met and deficiencies, if any, are resolved well before reaching a stage when they could be unacceptable. For this purpose, inspection and confirmatory checking shall be performed to verify compliance. A few examples that need verification during test performance are:

(i) test pre-requisites are in accordance with test procedures;
(ii) test equipment is appropriate to the task i.e. type, range, accuracy or any other requirement;
(iii) values of parameters (flow, pressure, temperature, neutron flux etc.) are within the proper range for initial conditions for the test;
(iv) special test equipment are installed properly and that relevant information on their calibration status etc. is recorded to enable, if necessary, interpretation of test results;

(v) requirements stated in the applicable operating procedures and the commissioning procedure for personnel and plant safety are complied with; and,

(vi) necessary documents and reports are available and approved by designated individuals.

Activities and aspects over which surveillance needs to be maintained, includes testing, identification and resolution of deficiencies, test documentation, document control, modification control, control of measuring and test equipment, cleanliness control, field change control, maintenance, personnel qualification and certification, flow of information from manufacturers and designers, and records.

8.13.4 Commissioning Status of items

Starting with the acceptance of an item for commissioning, the status of the item shall be identifiable through properly signed tags or other means at all times. As relevant, the aspects that need consideration are the following:

(i) deficiency, if any in the line up (configuration) of the system;
(ii) the remaining acceptance and performance testing before it can be considered suitable for sound operation;
(iii) the individual or organisational wing controlling the item at a particular time.

Installation and removal of tags shall be carried out as per approved procedures by designated persons.

8.13.5 Review of commissioning procedures and reports

A special consideration in the review include the inter-system and intra-system interfaces, relationship of this test to other commissioning activities, correlation with design intent, regulatory and other requirements and the statements concerning acceptance criteria. Direct participation of the design organisation in the review process is important and necessary.

8.13.6 Control of equipment configuration

During commissioning, configuration requirements for equipment (valve line up, interlock provisions, instrumentation and operability) could be different from normal operation. In some cases, relaxation may be permissible and, in some other, requirement may be more stringent. Where deviation has been authorised, the stage (or step) of commissioning before which normalisation is necessary, shall be stated and measures established to assure compliance.

In any case, all changes to configuration shall be in accordance with approved procedures and, with the approval of the designated individual in the operational shift. Actual status shall be known at all times to the control room and other appropriate persons/agencies.

8.13.7 Maintenance

Run-in aspects of equipment maintenance such as doweling and lubricant replacement should be included in the plan and implemented as per manufacturer's recommendation and good engineering practice.

8.13.8 Manpower training, qualification and certification

In order to enable satisfactory preparedness of operating personnel including members of the plant management and other key personnel, it is appropriate to ensure that these persons constitute the core of the commissioning group. For each organisational level the minimum requirement for the depth of coverage during the pre-criticality commissioning also called pre-operational testing, is more and breadth of coverage is less than in the Operation phase. Hence, arrangements are necessary to enable requisite training of operating personnel in accordance with requirements in Section 6.1 of Operation Code.

8.13.9 Non-Conformance Control and Corrective actions

An important aspect is the correlation of each non-conformance to commissioning or individual test sequence diagrams and identification of resultant hold points beyond which commissioning shall not proceed without corrective action being completed.

8.13.10 Review and Audits*

A review and audit plan for the commissioning phase shall be established in line with guidelines outlined in Sections 7.3, 7.4 and 7.5. Review and audit of activities important to Safety shall be carried out in a timely manner. Requirements to cross hold points shall be included in the plan.

***** It is recognised that progress of audit could lag behind performance and review of commissioning activities. The intent of including Audit as a hold point is to limit the lag to as low as practical.

9. RECORDS

9.1 A record system in conformance with Section 7 of the Code shall be established to cover the commissioning and operation phases.

Document for the purpose include:

(i) documents received from design, procurement, manufacturing and construction organisations including relevant QA records;
(ii) documents relevant to the commissioning phase such as plans, procedures, reports, reviews and resultant actions;
(iii) correspondence with AERB and other related documents;
(iv) Quality Assurance audit records related to commissioning and operation phases;
(v) equipment history cards, surveillance test reports, in-service inspection reports, maintenance and modification reports;
(vi) manpower training, qualification, certification and medical examination records;
(vii) periodic and special reports;
(viii) radiation exposure, effluent releases, waste management and environmental monitoring records;
(ix) modification including approvals;
(x) procedures including ad-hoc and periodic reviews;
(xi) As-built drawings showing modifications carried out; and
(xii) Non-conformance records and corrective actions taken.

9.2 Categorisation of Records

Two categories of records shall be established – permanent and non-permanent.

9.2.1 Permanent Records

Permanent records shall be maintained by or for the responsible organisation for at least the life of the particular item which is installed in the plant or stored for future use. The permanent records are those which are of significant value to meet one or more of the following objectives:

(i) To demonstrate capability for safe operation
(ii) To enable maintenance, rework, repair, replacement or modification of an item
(iii) To determine the cause of an accident or malfunction of an item
(iv) To provide required baseline data for ISI
(v) To facilitate decommissioning.

9.2.2 Non-permanent Records

Non-permanent records are those which are not needed to satisfy the requirements for permanent records but which are necessary to demonstrate the accomplishment of activities in accordance with the specified requirements. As a minimum, current records shall be maintained.

9.3 A typical list of records that has been in use in some power stations is given in Annexure II as an illustrative example.

ANNEXURE-I

A Typical List of Possible Indicators

A Overall Performance Indicators

1. Equivalent Availability Factor
2. Safety System Performance
3. Unplanned Automatic Scrams While Critical
4. Unplanned Safety System Actuations
5. Forced Outage Rate
6. Thermal Performance
7. Fuel Reliability
8. Collective Radiation Exposure
9. Volume of Low-Level Solid Radioactive Waste
10. Industrial Safety Lost-time Accident Rate

B Other Indicators

11. Corrective Maintenance Backlog Greater than Three Months Old
12. Preventive Maintenance Items Overdue
13. Ratio of Preventive to Total Maintenance
14. Maintenance Overtime Worked
15. Maintenance Radiation Exposure
16. Lost-time Accident Rate for Personnel Involved in Maintenance
17. Unplanned Automatic Scrams While Critical Associated with Maintenance Activities
18. Total Skin and Clothing Contaminations

19. Positive Whole Body Counts

20. Chemistry Performance

21. Percentage of Time Auxiliary Cooling Water and Other Standby Systems are Out of Spec.

22. Condensate or Feedwater Dissolved Oxygen Level

23. Steam Generator, Feedwater, or Reactor Water Conductivity

24. Condenser Air Inleakage

25. Unplanned Automatic Scrams per 1000 Hours Critical

26. Emergency Generator Unavailability Factor

27. Out-of-Service Control Room Instruments

28. Number of Safety Related Unusual Occurrences

ANNEXURE-II

A Typical List Of Quality Assurance Record Retention

Pre-operational and Commissioning records	Permanent	Non-Permanent
Automatic emergency power source transfer procedures and results	*	
Final system adjustment data	*	
Flushing procedures and results		*
Hydrostatic and proof test pressure test procedures and results	*	
Leak test procedures and results		*
Initial heatup, hot functional and cooldown procedures and results	*	
Hot conditioning procedures and results	*	
Initial fuel loading data		
Initial reactor criticality test procedures and results	*	
Instrument power supply systems and Control UPS test procedures and reports	*	
Main and auxiliary power transformer test procedures and results	*	
Off-site power-source energising procedures and test reports	*	
On-site emergency power source energising procedure and test reports	*	
Plant load ramp change data	*	
Plant load step change data	*	

Pre-operational and Commissioning records	**Permanent**	**Non-Permanent**
Power transmission substation test procedures and results	*	
Pre-operational system test procedures and results	*	
Reactor protection system tests and results	*	
Startup logs	*	
Startup problems and resolutions		*
Startup test procedures and results	*	
Station battery and DC power distribution test procedures and reports	*	
System lubricating oil flushing procedures	*	
System Water chemistry reports	*	
Operational phase activity records		
Safety Related Unusual Occurrence Reports (SRUORs) records	*	
Changes made in the operating procedures		*
Currently employed plant staff member qualifications, experience, training and retraining records	*	
Minutes of meetings of the SORC and plant related safety committees	*	
New and spent fuel inventory, transfers of fuel and assembly histories	*	
Normal nuclear unit operation, including power levels and periods of operation at each power level		*
Off-site environmental monitoring survey records	*	

Pre-operational and Commissioning records	Permanent	Non-Permanent
Periodic tests, inspections and calibrations QA audit reports		*
Plant radiation and contamination survey records	*	
Principal maintenance activities, including inspection repair, substitution or replacement of principal items or equipment pertaining to nuclear safety		*
Radioactive shipment records		*
Radioactivity levels of liquid and gaseous waste released to environment	*	
Radiation exposure records of all plant personnel and others who enter radiation control areas	*	
Reactor coolant system in-service inspection records	*	
Records and drawing changes reflecting plant design modifications made to systems and equipment described in the final safety analysis report	*	
Special reactor test or experiment records		*
Transient or operational cycling records for those plant components that have been designed to operate safely for a limited number of transients or operational cycles.	*	

ANNEXURE-III

A Typical List of Next Tier Documents
N.P.P. Procedures

An attempt is made here to cover typical activities (topics) that should be covered by written procedure by any N.P.P. Idea is to provide written procedures for all safety related activities as far as possible. The lists given here are not exhaustive and are not intended to be all inclusive listing of all needed procedures and are only for illustrative purposes.

Procedures are grouped under five categories:-

A. General Procedures which are generally common and applicable to all the sections of N.P.P.

B. Procedure for combating various emergencies

C. General Operation Procedure

D. Performance procedures specific to various sections

E. I.S.I. Procedure

F. In the end Governing documents which govern and provide basis for these procedures are given.

A. General Procedures

1. Security and access control procedure

   - Access to Plant Site
   - Access to Control Room
   - Access to Reactor Building

2. Organisation, Authorisation and Responsibility document

3. Authority and Responsibility of Shift Charge Engineer

4. Shift Change over procedure

5. Transfer of Authority during Emergency Conditions

6. Emergency Preparedness procedures for

   - Plant Emergency
   - Site Emergency
   - Off-site Emergency

7. Procedures for Jumpering or Bypassing

8. Equipment Control Procedure (e.g. locking & tagging, etc.)

9. Procedure for Writing Operation Manuals

10. Procedure for Writing Maintenance Manuals

11. Procedure Review and Modification Method

12. Plant Modification Method

13. Procedures for Log and data sheet entries, their review and retention

14. Housekeeping and cleanliness control

15. Preventive Maintenance schedule and routines

16. Schedule and Routines for surveillance, testing and calibration

17. Licensing and qualification procedures for all sections officers and staff

18. Procedure for handling radioactive materials

19. Procedures and schedule for internal QA Audit of Operation, Maintenance, Technical Unit, Physics, Health Physics, Chemistry, Fuel Handling, etc.

20. Procedure for issuing ECNs, Technical Bulletins, SRUORs, etc.

21. List of all logs being maintained in Control Room and Field

22. List of all Data sheets being regularly filled in Field and Control Room

23. List of formats and OFS forms, etc. applicable at Plant Site

24. Other forms related to work permit like DR cum Work Permit, Order to operate forms, cutting and wielding permit form, Radiological work permit form, Industrial Safety Permit form

25. Work Authorisation Procedure.

B. Procedure for Combating Emergencies

1. Loss of Coolant Accident

   - Large LOCA (Inlet Header Failure)
   - Medium LOCA (End Fitting Failure or Feeder Failure)
   - Small LOCA (Any Tube Failure e.g. DN Monitoring Tube or S.G. Tube Failure, etc.)
   - Coolant Tube Failure
   - Bleed Cooler Failure

2. Loss of Primary Coolant Flow (PCP Failure or Feed Pump Failure)

3. Loss of Shutdown Cooling

4. Loss of Process Water

5. Loss of Raw Water

6. Loss of Feed Water

7. Loss of Moderator Pumping System

8. Mod. HX Tube Failure

9. Loss of Condenser Water

10. Loss of Condenser Vacuum

11. Loss of Instrument Air

12. Loss of Service Air

13. Loss of Electric Power

    - Class IV Failure
    - Class III Failure
    - Class II Failure
    - Class I Failure

    And their combinations

14. Loss of containment integrity

15. Fuel Cladding failure or high activity in coolant

16. Activity in steam to turbine

17. Abnormal release of radioactivity

18. Malfunction of Pressure Control

19. Malfunction of Level Control

20. Malfunction of Regulatory System (LOCA)

    - Control Rod drifts or drops
    - Inability to drive Control Rods
    - Failure of Position Monitoring System

21. Failure of Primary Shutdown System

22. Failure of Secondary Shutdown System

23. Loss of Protective System Channel

24. Failure of Emergency Core Cooling System

25. Loss of Fire Protection System

26. Plant Fires

27. Fire in Control Room

28. Acts of Nature (e.g. tornado, flood, earthquake, cyclone, storm, etc.)

29. Acts of Sabotage

30. Various kinds of fueling M/C. failures, Fuel Transfer System failure etc.

31. Header Level Control Failure

32. Accident Opening of IRVs

33. Bleed Valve Stuck Open

34. Malfunctioning of S.D.V.s.

C. General Operating Procedures

1. Cold shutdown to hot standby
2. Operation of hot standby
3. Hot standby to minimum load
4. Changing load and load following
5. Plant shutdown to hot standby
6. Hot standby to cold shutdown
7. Recovery from reactor trip
8. Preparation for refueling and refueling operation.

D. Performance Procedures

In addition to general and emergency procedures given above, each section (viz. operations, maintenance, technical unit, physics, health physics, chemistry, fuel handling, etc.) has to write detailed procedures/manuals for all activities important to safety being done in that sections. QA manuals in addition to giving list of general, administrative and emergency procedures prepared by plant site, should also give list of performance procedures written by each section at the plant site. For example, QA manual should give,

1. List of Operation Manuals prepared and to be prepared by Operation Section

2. List of Maintenance Manuals prepared and to be prepared by Maintenance Section

3. List of procedures prepared and to be prepared by Physics Section

4. List of Health Physics Procedures prepared and to be prepared by Health Physics Section

5. List of procedures prepared and to be prepared by Technical Unit

6. List of procedures prepared and to be prepared by Chemistry Section

7. List of procedures for Fuel Handling Section

8. List of procedures for QA Section.

E. I.S.I. Procedures

1. Procedures for visual examination of welded joints, pipes, fittings, valves, hanger supports, rotor blades, HX tubes, etc.

2. Various procedures for liquid penetrant examination

3. Various procedures for Magnetic Particle Testing

4. Various procedures for Radiographic examination

5. Various procedures for Ultrasonic examination (e.g. Class I & II Terrific Steel Piping Welds)

6. Various procedures for Eddy Current Testing (e.g. single frequency and double frequency E.C. Testing of Heat Exchanger Tubing)

7. Procedure for Coolant Channel Axial Creep measurement

8. Fresh Fuel Bundle Helium Testing

9. Procedure for Helium leak testing for PHT, Moderator System Piping and HXs Tubing, etc.

10. Coolant Channel Visual examination procedure

11. Garter Spring Location procedure

12. Coolant Tube Calandria Tube gap measurement procedure

13. Coolant Tube Thickness Measurement procedure

14. Procedure for Air Hold Test/Pneumatic Test of Various Systems

15. Procedure for Hydro Tests

16. Various Welder Qualification Procedures

17. Various Welding Procedure and their qualification records

18. Welder qualification and records.

F. Governing Documents

1. Technical Specifications
2. Station Policies
3. Station Protection Code
4. Radiation Protection Manual
5. Quality Assurance Manual
6. Emergency Preparedness Procedure
7. Safety Analysis Report
8. Design Manuals
9. Training Manuals
10. Operation Flow Sheets
11. Licensing & Qualification Procedures.

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Dates of the Meeting: 4th, 15th and 22nd January, 1990
13th February, 1990
5th April, 1990
22nd April, 1992
5th, 14th May, 1992
24th July, 1992
11th August, 1992

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17th December, 1992
28th January, 1993

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