AERB SAFETY GUIDE NO. AERB/SG/QA-4

QUALITY ASSURANCE DURING SITE CONSTRUCTION OF NUCLEAR POWER PLANTS

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Price:

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FOREWORD

Safety of the public and occupational workers, and the protection of environment should be assured while activities for economic and social progress are pursued. These activities include the establishment and utilisation of nuclear facilities and the use of radioactive sources. They have to be carried out in accordance with relevant provisions of the Atomic Energy Act, 1962.

Assuring high safety standards has been of prime importance since the inception of the nuclear power programme in the country. Recognising this aspect, the Government of India constituted the Atomic Energy Regulatory Board (AERB) in November 1983. The Board has been entrusted with the responsibility of laying down safety standards and framing rules and regulations in respect of regulatory and safety functions envisaged under the Atomic Energy Act. Under its programme of developing safety codes and guides, AERB has issued four codes of practice in the area of nuclear safety 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

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 other than 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 risks to the health and safety of the plant personnel, the general public and the environment.

Codes and safety guides may be revised as and when necessary in the light of experience as well as relevant developments in the field. The annexures and footnotes are not to be considered as integral parts of the document. These are included to provide information that might be helpful to the user.

The emphasis in codes and guides is on protection of site personnel and public from undue radiological hazards. However, for aspects not covered in the codes

and guides, applicable and acceptable national and international codes and standards shall be followed. In particular, industrial safety shall be assured through good engineering practices and compliance with the Factories Act, 1948 as amended in 1987 and the Atomic Energy (Factories) Rules, 1996.

This Safety Guide is one of a series of guides which have been issued or are under preparation as a follow-up to the Code of Practice on Quality Assurance for Safety in Nuclear Power Plants (AERB/SC/QA). It prescribes guidelines on quality assurance during site construction of nuclear power plants in India and is intended for the Construction Organisation of nuclear power plants.

This Safety Guide has been prepared by the staff of AERB and other professionals. In drafting the guide, relevant International Atomic Energy Agency (IAEA) documents under the Nuclear Safety Standards (NUSS) programme, especially the Safety Guide on Quality Assurance in Construction (50-G-Q11, 1996) have been used extensively. It has been reviewed by experts and vetted by AERB Advisory Committees before issue. AERB wishes to thank all individuals and organisations who have contributed in the preparation, review and finalisation of the Safety Guide. List of persons who have participated in the committee meetings, along with their affiliation is included for information.

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(Suhas P. Sukhatme)
Chairman, AERB

DEFINITIONS

Acceptable Limits

Limits acceptable to Regulatory Body for accident condition or potential exposure.

Accident Conditions[1]

Substantial deviations from Operational States which could lead to release of unacceptable quantities of radioactive materials. They are more severe than anticipated operational occurrences and include Design Basis Accidents and severe accidents.

Active Component

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. Examples of Active Components are pumps, fans, relays and transistors. It is emphasised that this definition is necessarily general in nature as in the corresponding definition of Passive Component. 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.

Approval

Formal consent issued by Regulatory Body to a proposal.

Applicant

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

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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.

Atomic Energy Regulatory Board (AERB)

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

Audit

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

Authorisation

A type of regulatory consent issued by the Regulatory Body for all sources, practices and uses involving radioactive materials and radiation generating equipment.
(See also Regulatory Consent)

Commissioning

The process during which structures, systems and components of a facility, having been constructed are made operational and verified to be in accordance with design specifications and to have met the performance criteria.

Commencement of Operation

The specific activity/activities in the commissioning phase of a Nuclear Power Plant towards first approach to criticality starting from fuel loading.[2]

Competent Authority

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

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2 e.g. Fuel Loading in case of light water reactors and in case of pressurised heavy water reactors, heavy water addition with fuel already loaded.

Construction

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

Decommissioning

The process by which a facility is finally taken out of operation in a manner that provides adequate protection to the health and safety of the workers, the public and the environment.

Design

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

Design Basis Accident (DBA)

Design Basis Accidents are a set of postulated accidents which are analysed to arrive at conservative limits on pressure, temperature and other parameters which are then used to set specifications that must be met by plant structures, systems and components and fission product barriers.

Design Inputs[3]

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

Design Outputs[3]

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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3 The definitions refer to Quality Assurance activity as discussed in Quality Assurance Code and Guides.

Diversity

The existence of redundant components or systems to perform an identified function, where such components or systems collectively incorporate one or more different attributes.[4]

Documentation[3]

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

Electrical Separation

Means for preventing one electric circuit from influencing another through electrical phenomena.

Emergency Electric Power Supply (EEPS)

That portion of the Emergency Power Systems provided for the purpose of supplying electric power to the safety systems during Operational States as well as during and following Accident Conditions.

Examination[3]

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.

Fuel Bundle

(Also called Fuel Assembly).

An assembly of fuel elements identified as a single unit.

Independence

Independence of equipment, channel or a system is its ability to perform its function irrespective of the normal or abnormal functioning of any other

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4 Examples of such attributes are: different operating conditions of uses, different size of equipment, different manufacturers, different working principles and types of equipment that use different physical methods.

equipment, channel or system. Independence is achieved by functional isolation and physical separation.

Inspection[3]

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[3]

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

Items Important to Safety

The items which comprise:

(1) those structures, systems, equipment and components whose malfunction or failure could lead to undue radiological consequences at plant site or off-site;[5]

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

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

Normal Operation

Operation of a plant or equipment within specified Operational Limits and Conditions. In case of nuclear power plant this includes start-up, power operation, shutting down, shutdown state, maintenance, testing and refuelling.

Nuclear Power Plant

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

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

Nuclear Safety

Protection of all persons from undue radiological hazard.

Objective Evidence

Term used in context of Quality Assurance, 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 Organisation (O_PO)[6]

The organisation so designated by responsible organisation and authorised by Regulatory Body to operate the facility.

Operating Personnel

Those members of site personnel who are involved in the operation of the NPP.

Operation[7]

All activities following commissioning and before decommissioning performed to achieve, in a safe manner, the purpose for which the installation was constructed, including maintenance.

Physical Separation

A means of ensuring independence of an equipment through separation by geometry (distance, orientation etc.), appropriate barriers or combination of both.

Plant Management

The members of site personnel who have been delegated responsibility and authority by the Operating Organisation for directing the operation of the plant.

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6 Organisation structure and not individual names.

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

Postulated Initiating Events[8]

Identified events that lead to Anticipated Operational Occurrences and Accident Conditions and their consequential failure effects.

Protection System

A part of Safety Critical system which encompasses all electrical, mechanical devices and circuitry, from and including the sensors up to the input terminals of the safety actuation system and the safety support features, involved in generating the signals associated with the safety tasks.

Quality

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

Quality Assurance

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

Quality Control

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

Region

A geographical area, surrounding and including the site, sufficiently large to contain all the features related to a phenomenon or to the effects of a particular event.

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8 The primary cause of postulated initiating events may be credible equipment failures and operator errors (both within and external to the Nuclear Power Plant), Design Basis Natural Events and Design Basis External man-made Events. Specification of the postulated initiating events should be acceptable to the Regulatory Body.

Regulatory Consent

It is a written permission issued by the Regulatory Body to perform the specified activities related to the facility. The types of consent are 'License', 'Authorisation', 'Registration' and 'Approval' and will apply depending upon the category of the facility, the particular activity and radiation sources involved.

Reliability

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

Safety (See Nuclear Safety)

Protection of all persons from undue radiological hazard.

Safety Function

A specific purpose, that must be accomplished for safety.

Safety Critical System (Safety Systems)

Systems important to safety, provided to assure, under Anticipated Operational Occurrences and Accident Conditions, the safe shut down of the reactor (Shutdown System) and the heat removal from the core (Emergency Core Cooling System), and containment of any radioactivity (Containment Isolation System).

Safety Support System or Safety System Support Features

Part of Safety Critical Systems which encompasses all equipment that provide services such as cooling, lubrication, and energy supply (pneumatic or electric) required by the protection system and safety actuation systems.

Severe Accidents

Nuclear Power Plant conditions beyond those of Design Basis accident causing significant core degradation.

Single Failure

A random failure which results in the loss of capability of a component to perform its intended safety function. Consequential failures resulting from a single random occurrence are considered to be part of the Single Failure.

Site

The area containing the facility, defined by a boundary and under effective control of the facility management.

Ultimate Heat Sink

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

CONTENTS

1. INTRODUCTION

1.1 General

1.1.1 This Safety Guide forms part of the Atomic Energy Regulatory Board's (AERB) programme for establishing Codes, Guides and other standards for assuring safety during site construction of land-based stationary nuclear power plants based on thermal reactors (NPPs) in India. It provides guidance on the establishment of a Quality Assurance Programme (QAP) during site construction phases. It is recognised that multi-unit sites would have some units under construction and others under commissioning/operation. The units under construction shall comply with the requirement 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) hereafter referred to as the Code, form the basis of this Safety Guide. After review as required, AERB may impose any additional requirements.[1]

1.1.3 Methods/solutions and recommendations other than those set out in this Safety Guide may be accepted provided they meet with the requirements of AERB/SC/QA and result in at least the same level of safety.

1.2. Objective

This Safety Guide provides recommendations on how to fulfil requirements of the code in relation to the construction stage of nuclear power plants.

1.3. Scope

1.3.1 This Safety Guide applies to Quality Assurance (QA) programmes of the Responsible Organisation (RO) as well as to any other separate programmes in the construction stage of an NPP project, covering items, services and processes impacting safety. It may also be usefully applied to major retrofits and nuclear facilities other than NPPs.

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1 Examples: activities like coolant tube replacement, steam generator tube replacements etc.

1.3.2 This Safety Guide relates to construction stage of an NPP. It also applies to major modifications carried out on NPP which has been in service. The construction stage overlaps with other NPP stages such as design and commissioning. RO may separate these stages or combine them in one organisation. Irrespective of the organisational arrangement utilised, the responsibilities and interfaces must be clearly defined and understood and the status of the plant established at all times.

1.4 Document Arrangements

Statements in the Code of Practice No. AERB/SC/QA are not repeated for brevity and it is assumed that the user would refer to the Code while referring to this document for formulation and implementation of the Quality Assurance Programme.

2. MANAGEMENT FUNCTIONS

2.1 Quality Assurance Programme (QAP)

2.1.1 RO should develop and implement a QAP which describes the overall arrangement for the management, performance and assessment of the NPP construction. This programme should also provide the means to ensure that all work is suitably planned, correctly performed, assessed and documented.

2.1.2 The QA manual which outlines the basis of the QAP should be submitted to the regulatory authorities for review and any check or hold points required by regulatory authorities should become part of the QA plans.

2.1.3 RO should establish procedure for control of construction activities at the site to ensure that the construction of the plant fulfills specified requirements (Annexure-I). Arrangements should be made to ensure that these procedures are reviewed and approved before issue and that subsequent amendments are controlled.

2.1.4 RO may delegate and/or require contractors or other organisational units to develop and implement all or part of the programme but shall retain overall responsibility for implementation and effectiveness of the programme.

2.1.5 Where delegated, the contractor(s) or other organisational units should prepare QAP for the work they will be responsible for and submit them to RO for approval, prior to any work being carried out. Any changes to these programmes following initial approval shall be submitted to RO for approval.

2.1.6 Requirement of QA Manual

In addition to control parameters, QA manual should contain the following:

A. list of procedures

B. list of permanent and temporary records

C. QA manual should call for preparation of the following documents prior to start of construction:

1. list of QA plan defining responsibilities of agencies at the interfaces.
2. list of instruments to be calibrated with identification of agencies, who will calibrate the instruments.
3. QA manuals, if any, for individual works, cross reference should be provided.
4. list of level III networks of various construction activities.
5. list of safety-related items (QA manual for individual works should identify safety-related items suitable for use by shop floor/field personnel).
6. list of items of all the activities, mechanical, electrical, reactor piping, instrumentation and civil to be covered in pre-service inspection (PSI), for the purpose of in-service inspection (ISI).

2.2 Grading[2]

While safety should be the fundamental consideration in determining the extent of QA requirements to be applied, a graded approach should be used for each item, service or process.

The most important factor in determining the extent of QA efforts is the effect of an error in service or the malfunction or failure of an item on safety. Other factors for consideration include the following:

(a) complexity or uniqueness of the item;

(b) degree of standardisation of the item;

(c) need for special controls, administrative measures and surveillance over processes, methods and equipment;

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2 For information on grading see IAEA Technical Report Series No.328.

(d) degree to which compliance with design requirements can be demonstrated by inspection and test;

(e) quality history;

(f) accessibility of the item, after installation in the plant, for maintenance, in-service inspection and replacement; and

(g) economic implications of failure.

A typical graded classification of QA levels for construction stage is given in Annexure-IV.

Special aspects in construction phase that could be graded are:

- qualification of special construction process or personnel to carry them out;
- extent and details of procedures and degree of their review;
- degree in process controls, hold points and sample points;
- requirements of material traceability; and
- pre-service inspection.

2.3 Organisation

2.3.1 RO should appoint a construction organisation to manage, coordinate and supervise NPP construction.

2.3.2 Construction organisation is responsible for ensuring that:

- construction and installation work (including procurement and pre-commissioning) is carried out in accordance with design specifications, drawings and procedures, including implementation of the specified QAP;
- construction and installation work undertaken including work by contractors is coordinated, conducted and completed in accordance with planned programme of work; and
- access to construction site is controlled.

2.4 Interfaces

2.4.1 Interface arrangement should be agreed with construction organisation, contractors and other organisational units performing the work. They should be defined in writing and may be included in the contract documentation. Interfaces that should be addressed include :

- contractor and construction organisation;
- contractor and test and commissioning personnel or organisation;
- interfaces with sub contractors;
- interfaces with design authority, corporate QA, health and safety, etc;
- interfaces with siting organisation; and
- construction organisation and regulatory body.

2.4.2 Appropriate arrangement should be specified for communication of quality problems or other matters requiring special attention. The form of communication should be specified.

2.5 Training and Qualification

Persons performing, inspecting, verifying or assessing should be competent to ensure that the work meets specified requirements.

All personnel performing activities affecting the quality of items should be qualified on the basis of general education, experience and proficiency required for performing the specified assigned tasks. They should also be familiarised with work instructions, special equipment, QAP requirements and procedures. Where required by codes, standards, specifications or other special requirements, personnel performing activities affecting quality, (e.g., non-destructive examination personnel, welders and welding operators, special process like tube rolling, etc.) shall be certified as per applicable codes, standards, etc.. The certificate shall be valid for a stipulated period and where necessary be conditional on similar work being performed to maintain proficiency. Re-certification shall be required before the individual is assigned the task after expiry of the stipulated period.

Training and qualification should be conducted as per written procedures.

2.6 Planning

2.6.1 All activities important to safety during construction including verification activities shall be planned, documented and approved in advance. The plan should define activities to be performed in manageable units (work breakdown structure), the planned sequential order and duration of these activities and the resource allocation for each activity. Computer aided planning is desirable.

2.6.2 Construction organisation should be responsible for coordinating and planning the overall construction of NPP. Contractors should be responsible for producing detailed plans of work under their control and shall obtain prior approval from the construction organisation.

Construction and commissioning plans/schedules should be updated whenever necessary and at least once in a year.

2.6.3 Deficiencies pointed out during planning should be brought to the attention of construction organisation for corrective actions.

2.6.4 Planning should consider requirements for site fabrication, installation, inspection and pre-commissioning testing of structures, systems and components important to safety such as the need for:

- identification, preparation and control of procedures and work instructions;
- special equipment or materials;
- competent personnel;
- procedures and mockup trials for handling and installation of critical components; and
- special storage provisions and periodic inspection for some critical components.

These requirements should be identified by examining specifications for structures, systems and component design, procurement documents and

drawings, and the construction work plans and schedules. This examination should be done to ensure that activities can be accomplished as specified.

2.6.5 Wherever new installation methods are to be used, the adequacy of the same should be confirmed by the construction organisation.

2.6.6 Periodic work progress reports are issued and such reports are reviewed by appropriate level of personnel to adopt new technologies in various methods of construction and testing.

2.7 Non-Conformance Control and Corrective Actions

2.7.1 Measures shall be established to assure compliance with Section 6 of the Code. Non-conformances that are required to be reported and recorded should be identified by the construction organisation. Before taking any remedial action the cause of defective work and proposed corrective action to prevent re-occurrence should be agreed with the construction organisation (see Figure 1).

2.8 Document and Record Control

2.8.1 Construction organisation shall establish a system for controlling documents containing information necessary to ensure that the construction of NPP fulfills specified requirements.

2.8.2 A record system should be established which includes arrangements and responsibilities for categorisation, receipt, review, indexing, storage, retrieval and disposition of construction records.

2.8.3 A schedule of records should be prepared identifying handover to the organisation responsible for commissioning/operating of the plant on completion of all construction work.

2.8.4 A typical list of procedures, records and checklist is given in Annexures V to XIII

2.9 Internal Review Committee for QA and Safety

Construction organisation should form a local QA and safety review committee to discuss and resolve issues connected with safety and quality during construction. This committee should meet as and when required or at least once in a month and should include senior members from departmental construction group, QA, industrial safety, commissioning/O&M and the designer's representative. The committee should be chaired by the head of construction organisation at site.

3. PERFORMANCE FUNCTIONS

3.1 General

3.1.1 Construction and installation work may be executed by construction organisation directly or through contractors. Guidelines given in the safety guide should be applicable for all the agencies.

Whether the work is done by the contractor or the construction organisation itself, the construction personnel should be responsible for the following activities:

(a) supervision and control of departmentally executed work and works done by contractors;

(b) to ensure that contractors are established at site in a controlled manner, in allocated areas and wherever required, to provide them with necessary site services, information and instruction regarding applicable industrial safety aspects;

(c) to prepare and issue safe working procedures including industrial safety to all concerned personnel of construction organisation and the contractor. It should be ensured that contractor's site safety arrangements are as per applicable documents, codes, etc.;

(d) monitoring industrial safety policies and activities of all personnel on construction site in order to ensure compliance with statutory and regulatory requirements;

(e) planning and monitoring the progression of work to achieve the completion to programme including wherever appropriate the coordination of activities of multi-discipline contractors;

(f) to ensure that all works are carried out in accordance with specifications and drawings, that QA requirements are implemented and installation checks are appropriate and in accordance with surveillance schedules;

(g) to arrange controlled transfer of completed work/documents from:

(i) one contractor to another contractor;

(ii) contractor to the construction organisation; and

(iii) construction organisation to commissioning/operation organisation.

3.1.2 In the construction phase of NPP, a lot of documents and records are received or generated by various organisations. Construction organisation should establish a document control centre with proper procedures for receipt, storage, change and retrieval of documents.

3.2 Procurement

3.2.1 Only those contractors who are qualified and experienced to carry out the work should be selected and employed for construction/installation work of the plant.

If information on qualified and experienced contractor is not available, the construction organization should prequalify contractors for various works and prepare a short list to whom tenders for concerned works should be issued. Before award of work, the prospective contractor should be briefed about special technical requirements including regulatory requirements.

3.2.2 For further guidelines on QA aspects for procurement of items and services reference may be made to AERB/SG/QA-2.

3.3 Start-up Meeting

After award of construction/installation contract a start-up meeting should be convened between the contractor and construction organisation to establish that contractor is fully aware of construction organisation's requirements for aspects such as methods of communication, documents and information to be submitted, housekeeping, site security, mandatory site training courses, safety (radiological, nuclear and industrial), QA, control of sub-contractors, common understanding of technical requirements etc.. Arrangement shall also be agreed upon for satisfying the above mentioned requirements.

3.4 Review of Contractors' Quality Assurance Documentation

Construction organisation should request from contractor complete schedule of submission of documents required for approval, identifying each document by title, reference and date required. Construction organisation should ensure that the schedule of all documentation requiring review and approval prior to commencing any activity is identified and suitably reviewed and approved. The schedule of documents should be maintained during the currency of contract. Typical documents covered may include contractor's QA programme, inspection and test plans, installation methods, operator qualifications, special process procedures and work instructions.

A history of review and approval of document submitted by contractor shall be maintained both by the contractor and the construction organisation.

3.5 Control of Design Information

Procedures should be established detailing lines of communication and arrangements for issue of design information among involved organisations. Construction organisation, before issue, should ensure that information being issued reflects the current site conditions. Special attention should be paid to information required at the off site fabrication facility.

Procedures should ensure that latest revisions of documents are used for site construction work.

3.6 Control of Design Change Information

A system should be established to address change request from contractor on the design information issued. Where the change request may have an impact on safety it should be addressed to design authority for resolution. Copies of all change requests should be sent to design authorities regardless of their content in order that the authority may gain field experience and also inform impact on safety, if any.

3.6.1 The response of design authority should be in the form of a Engineering Change Notice (ECN). A typical flow chart to control such ECN is given in Annexure-IX.

3.7 Approval of Sub-Contractors and Suppliers

Sub-contractor should be approved by construction organisation in respect of adequacy of contractors' proposed arrangement for controlling the quality of work or material concerned including details of any proposed inspection arrangement.

3.8 Housekeeping during Construction and Installation

Construction organisation should be responsible for establishing housekeeping and cleanliness procedures and their maintenance. To preserve the required quality of items during storage/construction/ installation/precommissioning, housekeeping procedure should be established and implemented in accordance with specified requirement. The procedure shall include proper cleanliness of site area, tools, handling gear, equipment being installed and also take into account the control of environmental condition and personnel access. Special attention should be paid for proper housekeeping during pre-assembling/ installation and precommissioning of reactor components.

Where clean zones are used to achieve the control, they should be clearly marked and instruction placed at the entrance as well as issued to regulate their access.

3.9 Activities Requiring Special Cleanliness Control

During construction of NPP, several activities require special cleanliness control. Construction organisation should specify cleanliness standards and dust control measures as unclean surface conditions and atmospheric dust can lead to failures in service. Construction organisation should also prepare procedures for maintaining these cleanliness standards and adherence to these procedures should be ensured while such activities are performed.

3.10 Industrial Safety

Construction organisation shall make adequate arrangements for industrial safety of all personnel working at site. It should ensure that all requirements of the Atomic Energy (Factories) Rules, 1996 are complied with. Special attention in this regard should be paid to work executed by contractors.

3.11 Physical Protection

Construction organisation shall take appropriate physical protection arrangements as soon as construction starts. Protection against external or internal malevolent action shall be provided by trained personnel. Consideration shall be given to access controls around the construction site at various stages of construction, establishment of procedures for access authorisation to critical areas of work, and selection and training of security personnel. Only authorised personnel under proper supervision should be allowed to enter critical work areas.

3.12 Control of Materials and Equipment

3.12.1 All material and components received at site should be as per the overall plan of construction of the project. This planning should take into account the need for properly constructed (covered/open) storage areas, suitability of packing for long duration storage, etc..

Receiving, storage and handling of equipments should be controlled through an established procedure to prevent their abuse, misuse, damage, deterioration or loss of identification.

3.12.2 Receiving

Material/equipment/items arriving at construction site should be physically inspected at the time of unloading to verify that there is no damage due to transportation, improper handling, environmental factors, etc..

After receipt, inspection should be carried out, in a timely manner, to ensure that items received meet all specified requirements such as identification and marking, documents are available as required, protective covers and seals are intact, coating and preservatives have not been damaged, no physical damage has occurred, cleanliness is of correct standard, inert gas blanket and condition of desiccant are maintained where necessary.

A receipt inspection/verification report should be prepared by a competent person which should also specify instructions for proper storage. The specification should define methods and conditions of storage to prevent corrosion, contamination, deterioration, physical damage etc..

3.12.3 Storage

All items should be stored as specified to segregate and protect materials/ parts and components prior to installation and use.

Storage areas should be established and controlled taking into account the following aspects:

- access to storage area;
- cleanliness and housekeeping practices;
- fire protection requirements;
- identification and marking of items for easy retrieval;
- protective requirements relating to coatings, preservatives, covers and sleeves;
- prevention of physical damage;
- removal from storage;
- environmental control (such as temperature and humidity);
- preventive maintenance;
- expiry date of consumables; and
- no security has been compromised.

Periodic inspection should be carried out by knowledgeable persons, as necessary, or at least once every six months to ensure that physical conditions are maintained. Construction organisation should pay special attention for non-conformances due to improper storage. All non-conformances shall be handled inaccordance with para 2.7.

These inspections may need to continue during commissioning and operation stages. If required handover arrangement should be established.

3.12.4 Handling

Transportation and handling of all materials and items should be done as per approved procedures. Engineering supervision should be assured while handling important materials/items. These procedures should take into account weight, size, physical configuration, surface finish, orientation, susceptibility to shock damage prescribed handling points etc.. In case of important/critical items, where handling operations are of a nature likely to cause damage, special device such as cartons, containers, protective devices, hoists, manipulators and transport vehicles should be considered for use. All lifting tackles and handling equipment should be tested and qualified before use on the job. They shall also be maintained and checked periodically as per statutory codes, and standards/procedures. Operators for handling equipment should be qualified in their use by experience or by special training.

Material parts and equipment procured by the construction organisation for the contractor should be controlled in accordance with the above referred para before to issue.

3.13 Measuring and Test Equipment

Equipment used to verify that items meet established specifications (e.g output, dimensions or any quantifiable measurement) should be controlled. This control should be applied to proper selection, identification, use and calibration requirements and calibration frequency of necessary equipment.

Identification of test equipment and its calibration status should be maintained on equipment or on records traceable to equipment.

Calibration should be carried out by authorised personnel in accordance with approved procedure and with recognised standards.

If any measuring and test equipment is found to be out of calibration, it should be identified, marked or segregated to prevent further use until it has been submitted for recalibration. Materials/items measured or tested by that equipment should be reviewed and disposition made in accordance with approved procedures.

3.14 Verification of Construction Work

Verification schedules and checklists should be prepared by construction organisation which should identify the level of inspection/verification requirement. This verification schedule should be made available in advance to all concerned.

Activities carried out by construction organisation personnel should not be considered as evidence of contractor's inspection. Construction organisation should issue, where necessary, procedures with standard forms for recording of contractor's inspection/verification activities. The verification method and acceptance criteria should be clearly identified.

Detailed guidance for installation, inspection and testing of soil, foundation, concrete and structural steel is given in Annexure-I of this guide.

Detailed guidance for installation, inspection and testing of mechanical equipment and items is given in Annexure-II of this guide.

Detailed guidance for installation, inspection and testing of instrumentation and electrical equipment is given in Annexure-III of this guide.

Construction organisation should form a group of experts from construction, commissioning, QA and design to do integrated verification of completion of construction of the systems. A typical checklist for integrated verification is given in Annexures-XIII and XIV of this guide.

A typical checklist for verification of completeness of piping circuit before pressure and leak test is given in Annexure-XII.

3.15 Handover and Transfer of Responsibilities

Construction organisation should devise procedures to control and coordinate handover of completed works from one contractor to another and to those responsible for commissioning/operation of the plant to maintain the integrity of the completed works. Completed works should be handed over in a systematic and phased manner. Handover of components and systems should be planned in advance. All documents to be transferred should be reviewed by construction organisation for completeness, accuracy, orderliness and suitability for permanent retention during the life of the plant. Any deficiency should be identified and resolved and it should be ensured that the status of items is clear. Only authorised personnel shall be allowed to certify the completeness and accuracy of work completion documents.

When construction organisation is satisfied that transfer can be accomplished, a joint check with commissioning organisation should be carried out of the transferred items and associated documentation. The design organisation or its site-representative should also verify the completeness of construction with reference to design intent, deviations etc.. All concerned parties identified in QA procedure of construction organisation should sign formally to indicate transfer of responsibilities. Guidance for takeover of responsibilities by the commissioning organisation is given in Section 8.5 of AERB/SG/QA-5.

Construction organisation should prepare a master list of construction completion documents of conventional and reactor plant works for monitoring and verification. A suitable system of coding e.g. USI, should be used to integrate various works.

Completion documents should include inspection/test document generated during construction at site and also the history of documents of works done at the place of manufacture. Special attention should be paid to include important correspondence, nonconformances and engineering changes.

4. ASSESSMENT[3]

4.1 General

Assessment activities should be planned in advance and should be done at appropriate stages to assure quality, to provide confidence and to take timely corrective actions.

Typical subjects for assessment by construction organisation should include: interfaces, safety management, material testing, contractors' audit procedures, training and qualification, housekeeping, preservation of completed work, generation, and maintenance of documents etc..

A typical list of stages/activities for audit/assessment is given in Annexure-X of this guide. A typical audit/assessment checklist is given in Annexure-XI.

4.2 Self-assessment by Management

To provide feedback to the management, construction organisation should separately and collectively assess the adequacy and effectiveness of the QA programme. Self-assessment should be done from time to time but at least once every 6 months.

4.3 Independent Assessment

Independent assessment should be made from time to time by the construction organisation but it should be done at least once a year. Special attention should be paid for assessment at the interface of various activities.

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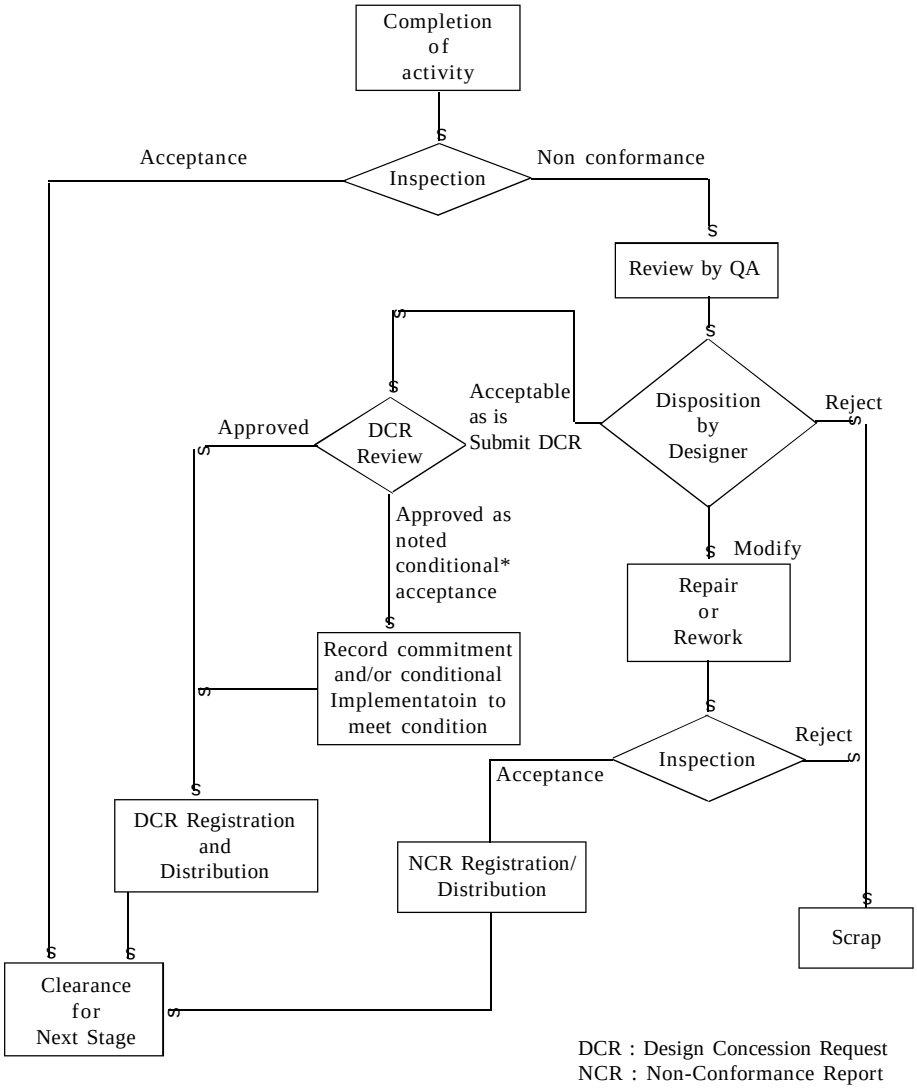
3 Under assessment all aspects of verification as given in Section 5.0 of AERB/SC/QA are included. For more detailed guidance on performance of assessment, reference could be made to AERB/SG/QA-6.



* After conditional acceptance of the design concession, no rework is envisaged on the non-conforming item

Fig. 1 : CONTROL OF NON-CONFORMANCE

ANNEXURE-I

TESTING OF SOIL, INSTALLATION, INSPECTION AND TESTING OF FOUNDATIONS, CONCRETE AND STRUCTURAL STEEL

I.1 General

Considering the safety of public at large, the concrete structure in NPP should meet special requirements regarding leak lightness, radiation shielding, temperature gradient in addition to static and dynamic loading. Therefore special attention should be given for inspection and quality control at all stages.

I.2 Preconstruction Verification

I.2.1 Material Verification:

Verification that materials meet specified requirements should be accomplished.

Tests necessary to qualify materials for normal application include those on materials such as concrete aggregates, cement and cement replacement materials, water and ice, curing compounds, concrete mixes, concrete admixture, soil, bitumen and reinforcement.

I.2.2 Verification of Construction Processes:

Prerequisites for control of construction processes such as welding, bolting and structural reinforcement splicing and for measuring, mixing, transporting, placing, consolidating and curing of concrete should be established. For these processes, the following should be verified:

(a) process has been qualified as required;

(b) process controls are in effect;

(c) approved procedures or instruction manuals are available for use during construction;

(d) process for the particular application has been approved;

(e) manpower, equipment and materials are available to perform the work in accordance with drawing and specification requirements;

(f) personnel are competent; and

(g) setting up of site concrete control laboratory.

I.3 Inspection of Soils, Rocks and Earthworks

Inspection of soils, rocks and earthworks and in-process inspection of placing and compacting operations should cover the following:

(a) materials such as stockpiles or borrow pits;

(b) placing and compacting equipment - to verify correct weight, type, operating conditions and vibration frequency;

(c) preparation for placement of fill - to ensure compliance with requirements for preparation of site and subgrade, so that the subgrade surface is, within specified limits, free of deleterious materials and voids, excess moisture, etc;

(d) soil compaction - to verify that; the fill material and its placement meet specified requirement; segregation of fill material does not occur as it is dumped and spread; the specified lift thicknesses are not exceeded; required watering is provided on each lift; compacting equipment makes specified number of passes over each lift; and passes overlap; and

(e) rock strata, where they are involved in foundations - to verify rock competence.

In-process tests should be performed during construction. If test results are erratic, or if trend of results indicates an apparent change in material characteristics, the frequency of tests should be increased.

I.4. Inspection of Foundation Piles and Caisson Construction

I.4.1 Foundation piles:

Inspection of foundation piles should include the following:

(a) receiving inspection and inspection to verify the handling, storage and transporting of piles;

(b) pile driving of wood, steel, pre-cast concrete piles and shells for cast-in-place concrete piles with permanent casing - to verify locations, positioning, correctness of pile hammer, pile type, cushioning material, pile driving process and sequence;

(c) concrete placement in cast-in-place piles with permanent casing - to verify before casting, casing conditions and straightness, dewatering of casing, if necessary, and amount and positioning of reinforcement; after placement of concrete, those verifications described in Section 4.5 of this Annexure;

(d) cast-in-place piles without permanent casing - to verify size, location and positioning of the pile, the amount and placement of concrete and the method of withdrawing the casing;

(e) composite piles and splicing piles - to verify alignment, cleanliness of interface, temperature limitations and splice installation; and

(f) test piles - to verify their drawing or construction, the load tests and their performance.

I.4.2 Caisson Construction

Inspection of caisson construction should include the following:

(a) caisson excavation - to verify dimensions of the shaft and location of the reamed bottoms of caissons; and suitability of supporting material, including absence of voids and caverns below caissons;

(b) caisson construction - to verify removal of loose soil, dewatering if applicable, concrete placement head, casing withdrawal method and methods of proportioning and placing concrete for slurry-stabilised caissons.

I.5 In-process Inspection and Testing of Concrete

I.5.1 General

Inspection and testing of concrete construction should include: inspection of preparations for concreting; in process inspections and testing of concrete measuring, mixing, transportation, placement, curing and protection; and where appropriate, testing for conformance to requirements. It should be recognised that requirements for inspection and testing will vary depending on the structural functions of concrete construction (e.g. containment building, foundation, pressure vessel) and that these differences should be taken into account in drawing up the programme.

I.5.2 Protection of Materials

Inspections should be performed to verify adequacy and maintenance of material storage conditions and handling techniques. These inspections should cover:

(a) cement storage facilities - to verify weather tightness, cement temperature and the absence of lumps: and review of records - to verify the type and age of cement;

(b) aggregate stockpiles - to verify that handling techniques do not result in segregation, that storage and handling prevent contamination, and that temperature and moisture controls are in operation;

(c) admixture storage and handling facilities - to verify shelf-life and check for deterioration and contamination; and

(d) water sources and cooling and heating facilities - to verify that specifications for water quality and concrete temperature are met.

I.5.3 Equipment for Measuring, Mixing and Transporting

Inspections should be performed before and during production of concrete to verify that measuring, mixing and transporting equipment are

as specified and that they are operated in accordance with established procedures.

These inspections should cover:

(a) measuring facilities - to verify accuracy of devices that measure, weigh or record :
    (i) proportions of cement, water and aggregates;
    (ii) nature and quantities of admixtures;
    (iii) aggregate moisture compensation;
    (iv) mixing time; and
    (v) temperature control;

(b) central mix plant and truck mixers - to check for excessive wear and/or malfunction.

I.5.4 Preplacement Preparations

Inspection of preparation for concrete placement should be performed. These inspections should cover:

(a) compacted structural fill before to placement - to verify that specified material has been used and to check the condition of material, gradation, moisture content, in-place density and compliance with compaction procedures;

(b) rock surfaces which will be in contact with structural concrete - to verify surface cleanliness, removal of loose rock and free water, correct contour, and specified subgrade condition;

(c) previously placed concrete - to verify preparation for the next fit;

(d) formwork and reinforcing - to verify: correct location and configuration of formwork; installation and integrity of water stops and membrane waterproofing; condition of form material to produce specified concrete finish; installation of ties, anchors, bracing, shoring and supports; correct size, orientation and installation of reinforcing steel; correct location and dimensions of control joints, expansion joints, construction joints, blockouts; form coating and cleanliness;

(e) welding and splicing operations for mechanical reinforcing bars; and

(f) inspection should cover the correct size, orientation, location and installation of the embedded parts.

I.5.5 Concrete Placement

Concrete placement should be inspected and should include verification that:

(a) specified tests of concrete have been performed;

(b) specified requirements are adhered to, regarding class of concrete, age, rate of placement, lift height, placing sequence and hot or cold weather concreting practice;

(c) conveying and placing equipment are used as specified;

(d) adequate concrete consolidation equipment, and appropriate techniques of operation are employed;

(e) embedded items are not disturbed nor forms displaced; and

(f) post-placement inspection is carried out and documented for proper setting.

I.5.6 Finishing and Repair

Inspections should be performed to verify that specified finishes, e.g. wood float, steel trowel or as-cast are obtained.

Any indications of voids or contamination, such as at a construction joint, should be explored, by physical removal of concrete, if necessary, to determine their extent and appropriate repairs made and documented.

I.5.7 Curing

Inspections should be performed throughout the specified curing period to verify that curing requirements are adhered to. Such inspections should cover:

(a) moisture control;

(b) temperature control;

(c) use of curing compounds;

(d) green cutting at appropriate time; and

(e) retention time of shoring and formwork.

I.5.8 In-process Tests on Concrete and Reinforcing Steel

In-process tests should be performed during construction to ensure that the concrete meets specified requirements. These should include tests on physical and chemical properties of base materials and finished products.

I.5.9 Inspection and Testing of Mechanical Splices

I.5.9.1 Qualification of Operators

Before splicing of reinforcing bars, each splicing operator or each crew (if the operators work as a crew) should perform qualification tests as required.

I.5.9.2 Inspections and Tests

All completed mechanical splices should be visually inspected after they have cooled to ambient temperatures. Splices that fail to pass visual inspection should be discarded and replaced and should not be used as tensile test samples.

Tensile tests should be performed at a specified frequency on either production splices, or test splices made at the same locations and under the same conditions.

I.5.10 Welded Reinforcing Bar Splices

Welded reinforcing bar splices should be subject to the inspection and testing requirements of section 6.5 of this Annexure.

I.5.11 Materials and Systems for Pre-stressing

All materials and systems used in pre-stressed concrete applications should undergo inspection in accordance with specified requirements. Equipment used in installation of pre-stressed tendons and windings should be tested and calibrated.

I.5.12 Pre-stress Level Monitoring of Concrete Pressure Vessel and Reactor Building

If stipulated by design documents, representative samples of pre-stressed structures should be identified for periodic monitoring of pre-stress levels during the life of the structures.

I.5.13 Seismic Tests for Concrete Pressure Vessel and Reactor Building

For seismic testing of concrete pressure vessel and reactor building, the reader is referred to the requirements and recommendations of Safety Guide 50-SG-S2 of IAEA.

I.5.14 Integrity/leak Rate Tests on Containment Building/Spent Fuel Storage Bay etc.

Integrity/leak rate tests on containment building etc. should be done in accordance with established and approved procedures.

I.6 Inspection of Steel Construction

I.6.1 General

Steel construction, which includes related items, such as anchor bolts and base plates and which forms part of the supporting structure or is installed as part of structural concrete work, should undergo inspection. Such inspections, should also cover: assembly, erection and alignment operations; fastening or connecting operations; and welding and finishing, including cleaning and protective painting or coating.

I.6.2 Supporting Structures

Anchor bolts, base plates and other structural embedments should be checked prior to erection of structural steelwork, for type, correct location, orientation, spacing and elevation. Base plate surfaces and supporting concrete surfaces should be checked before grouting to verify satisfactory condition. Grouting should be performed in accordance with approved procedures.

I.6.3 Assembly and Erection

Assembly and erection operations and equipment should be inspected to verify compliance with installation procedures and work instructions. Alignment operations and inspections should be carried out sufficiently early, and as often as necessary as erection progresses, to ensure that specified requirements are met with particular reference to environmental factors such as temperature.

Particular attention should be laid on verifying bolt hole alignment, the condition of contact surfaces of friction type connections and contact area of bearing surfaces.

I.6.4 High Strength Bolting

Bolts should be used and tightened in accordance with specification. Inspection of bolting should include visual inspection of bolting operations. Where load indicating washers or similar devices are used, inspection should ensure correct assembly. Hand-torque and impact-torque wrenches used for inspections should be tested and calibrated periodically.

I.6.5 Welding

Inspection of structural steel welding including reinforcing bar splices should include visual examination of preparations, welding processes, post-welding operations and non-destructive examination which is appropriate to the application. Before welding, it should be verified that

welding procedures are correctly selected and qualified. Welder qualification should also be verified. In-process inspection should cover joint fit-up prior to start of welding, preheat and interpass temperature requirements, filler material, control of distortion, and post-weld heat treatment and cleaning requirements.

Procedures should be established to control procurement, receipt, segregation, identification, distribution, storage and use of weld filler materials.

Weld repairs should be made by qualified welders in accordance with approved repair procedures and reinspected, as a minimum, by the same method which disclosed the defect. All such weld repairs should be documented.

ANNEXURE-II

INSTALLATION, INSPECTION AND TESTING OF MECHANICAL EQUIPMENT, PIPING AND SYSTEMS

II.1 Pre-installation Verification

II.1.1 Identification of Items

Inspection should be carried out to verify that the identity of mechanical materials and equipment received has been maintained and is in accordance with applicable approved drawings, equipment lists, specifications and established procedures.

Inspections should be performed to verify that a process for maintaining identification of mechanical items throughout construction has been established, and that it includes provisions for controlling substitution or exchange of equipment or materials. The process should provide appropriate identification of items by correlation to drawings, specifications or other records.

II.1.2 Verification of Installation Pre-requisites

Inspection should be performed to verify that processes and procedures are ready when needed for use in installation of mechanical items. These inspections or checks should include verifications that:

(a) approved procedures, drawings, manuals or other work instructions are provided to installer at the construction site;

(b) approved procedures and instructions for processes such as coating, welding, heat treating and non-destructive examination are available at site;

(c) where applicable, competent personnel are available;

(d) installation preparations have been completed, including such tasks as removal of packaging, conditioning, cleaning, protecting and preliminary positioning, as appropriate;

(e) jigs, fixtures and equipment for processes, as required, are available at site and conform to specified requirements;

(f) the equipment required for handing and placement of mechanical items is available at site;

(g) warnings and safety notices appropriate to the activity are posted; and

(h) approved procedures and equipment are available for carrying out verification activities, including dimension checks, where appropriate.

II.1.3 Physical Condition of Components

Inspections should be performed to verify that mechanical items at the point of installation are in accordance with the specified requirements.

These inspections should include verification that:

(a) protection measures and physical integrity during storage and handling have been maintained;

(b) non-conformances have been satisfactorily resolved; and

(c) items have been cleaned in accordance with specified requirements.

II.1.4 Site Conditions

Inspections should be performed to verify that conditions of installation area conform to specified requirements and that precautions have been taken to prevent conditions that would adversely affect items during installation.

These inspections should verify that:

(a) protection from adjacent construction activity is provided. Special attention is required for reactor/machined component erection in parallel with civil construction work;

(b) protection from inclement weather and other ambient conditions;

(c) materials that may be deleterious to mechanical items being installed are controlled;

(d) installation of mechanical items will not adversely affect subsequent installation activities;

(e) non-conformances whose correction could adversely affect installation of adjacent items have been resolved;

(f) adequate permanent, or approved temporary, supports and mountings have been installed, and will properly interface with the mechanical item; and

(g) servicing or maintenance activity related to installation has been performed.

II.2 Installation Process Control

Verification should be performed as appropriate to ensure that the equipment has been installed in accordance with requirements. Checklist should be used to avoid any omission.

II.2.1 Process and Procedure Control

Inspection should be made to verify that a system of process and procedure controls has been established and maintained at the construction site. Such inspections should include verification that:

(a) applicable procedures, drawings and instructions are being followed;

(b) approved processes, materials, tools and other equipment are being used;

(c) status of installation, inspections, examinations or tests is clearly indicated or identified in inspection records;

(d) installation, inspection and testing sequence is being maintained;

(e) non-conforming items are being controlled;

(f) as-built information is being recorded;

(g) inspection and test reports are current, accurate and complete; and

(h) personnel are qualified as required.

II.2.2 Inspection of Mechanical Items

Inspections of work areas and the work in progress should be performed to verify that mechanical items are being located, installed, assembled or connected in compliance with applicable approved drawings, manufacturer's instructions, codes, installation instructions and procedures. Inspections performed should include, as appropriate, verification of the following:

(a) identification of items;

(b) location and orientation of components;

(c) levelling and alignment;

(d) clearances and tolerances;

(e) tightness of connections and fastenings;

(f) fluid levels and pressures;

(g) absence of leakage;

(h) physical integrity;

(i) cleanliness;

(j) conditions of protective coating;

(k) welding operations, including materials and process controls, purging and removal of purge dams on completion;

(l) adequacy of protective measures to ensure that items will not be damaged during installation; and

(m) existence of barriers and protective equipment and of effective house-keeping to ensure that items will not be damaged or contaminated as a result of adjacent construction activities.

Non-destructive examination when required should be performed according to approved procedures. Techniques used in such examinations include: liquid penetrant, magnetic particle, ultrasonic, eddy current and radiography.

II.2.3 Installation Verification

Verification should be performed to ensure that mechanical items have been installed to specified requirements. If subsequent construction or associated activities affect the result of these verifications, they should be repeated.

Verification of conformance in the following areas should be included as appropriate:

(a) greasing and lubrication;

(b) cooling water systems;

(c) strainers;

(d) rotation of prime movers;

(e) electrical circuits, controls and relays;

(f) phasing of electrical busbars;

(g) calibration of instrumentation;

(h) valving and isolation;

(i) priming and venting;

(j) operating communication;

(k) isolation and control tags;

(l) piping system alignment;

(m) pipe hangers;

(n) restraints and dampers/snubbers;

(o) valve glands and packing;

(p) pneumatic line operation;

(q) valve stroking and actuation;

(r) pump seals and packing; and

(s) limit switches, interlocks and stops.

II.2.3.1 Cleaning of Fluid Systems and Associated Components

Requirements for cleaning of fluid systems and associated components and requirements for control of cleanliness should be established throughout construction. Cleaning and cleanliness control procedures should be prepared and should consider the following:

(a) identification of systems and subsystems with which procedures are to be used;

(b) work practices, house-keeping, access control and prevention of contamination and re-contamination;

(c) effectiveness of cleaning procedures for removal of contaminants;

(d) corrosiveness of cleaning solutions in contact with the material of an item, particularly in the case of dissimilar metals;

(e) chemical composition, concentration and temperature limits of any cleaning solutions and inhibitors used;

(f) identification of prohibited materials;

(g) solution and metal temperatures, solution concentrations, velocity and contact times during cleaning;

(h) methods for monitoring concentrations and temperatures of cleaning solutions during cleaning operations;

(i) sequence of operations and methods for filling, venting, fluid circulation, draining and flushing;

(j) equipment isolation, location of temporary piping and valves, location of strainers and location of temporary equipment;

(k) determination of construction operations that should be prohibited during cleaning operations;

(l) restrictions on usage and storage of potentially hazardous materials;

(m) methods for rinsing and neutralising, and specifications for rinses;

(n) methods for verifying cleanliness;

(o) methods for drying and preservation of equipment pending its use;

(p) methods for protecting installed equipment not involved in the cleaning operations;

(q) methods for disposal of cleaning solutions; and

(r) methods for maintaining cleanliness.

Special attention should be given to the following as appropriate:

(i) chemical conditioning: it should be verified that specified chemicals at the designated strength and temperature are being used for specified duration in the conditioning operations;

(ii) detection of foreign bodies in systems and components;

(iii) flushing: it should be verified that mechanical items are being flushed in accordance with specified requirements;

(iv) process controls: it should be verified that controls are being applied to the following:

  (a) temporary removal of parts from the system to facilitate flushing and re-installation;

  (b) installation and removal of temporary strainers, blind flanges and piping;

  (c) isolation of sensitive instrumentation; and

  (d) acceptance data, specimens or progressive samples, if required.

II.2.3.2 Pressure and Leak Testing

After completion of construction and at appropriate stage all mechanical items should be pressure and leak tested in accordance with specified requirements to ensure that:

(a) appropriate pressures, temperatures, test media chemistry and pressure test cycles are established;

(b) time duration at test pressure is as specified;

(c) provisions are available to protect instrumentation during testing and to isolate if necessary;

(d) items external to defined test boundary are protected to prevent inadvertent over-pressurisation;

(e) relief devices are available and are set to prevent system over pressurisation;

(f) relief valves operate correctly;

(g) piping, equipment and their supports are protected from hydrostatic loads as appropriate;

(h) the rate of pressurisation of system should be controllable to avoid over-pressurisation. If required, this aspect should be demonstrated before use; and

(i) other appropriate provisions for protection of personnel and equipment have been made.

II.2.4 Protective Coatings

Activities associated with painting or coating of items and surfaces for which coating is essential for the preservation of the quality of item, or for which the failure of coating could adversely affect plant safety, should be performed in accordance with approved procedures. Procedures should include surface preparation guidelines. Care should be taken that the nature and properties of painting or coating are such that they do not interfere with proper functioning, marking, tests or non-destructive examination. When paintings or coatings are applied, measures should be taken to avoid damage to nearby equipment. Special attention is required for painting of surfaces which will not be accessible in future, such as surfaces of hanger and support, flat bottom tank etc. facing the concrete.

II.2.5 Care of Items

Items on which inspection and testing activities are being performed should be protected from personnel traffic, weather and adjacent construction activities (such as concreting, sand-blastings, acid cleaning, welding, jack hammering, chipping, burning and stress relieving) that would adversely affect item or test results. Such protection should be provided by appropriate house-keeping practices, temporary packaging and by erection of barriers, protective covers and walkways.

ANNEXURE-III

INSTALLATION, INSPECTION AND TESTING OF INSTRUMENTATION AND ELECTRICAL EQUIPMENT

III.1 General

The programme of inspection and testing of electrical power, instrumentation and control equipment and systems should be similar to that followed in the case of mechanical systems during construction phase. The following items/equipment are also included:

(a) connecting cables and cable trays;

(b) electric and instrumentation containment penetrations;

(c) instrumentation sensing lines from process root valves up to and including input transducers;

(d) primary sensing devices (e.g. orifices, flow nozzles, venturi tubes, and reference columns);

(e) hydraulic, pneumatic and vacuum instrumentation;

(f) output control transducers, including tubing and piping;

(g) fluid systems associated with stand-by generators and transformer cooling systems;

(h) switchgear fluid systems;

(i) panels, enclosures and mountings; and finally

(j) computer interfaces.

III.2 Pre-installation Verification

Inspections should be performed as applicable to ensure that items and installations areas are in conformance with specific requirements. These inspections should verify that:

(a) materials and equipment are identified in accordance with applicable approved drawings, equipment lists and specifications;

(b) approved installation procedures, instruction manuals and any special work instructions required for specific equipment are available;

(c) protective measures have been maintained during storage;

(d) materials and equipment are free from physical damage, corrosion, contact contamination and condensation;

(e) appropriate tools and instruments, calibrated as applicable, are available for use; and

(f) installation personnel are competent.

III.3 Installation Control

Equipment, cables and tubes should be installed in accordance with approved drawings, manufacturer's instructions and installation specifications and procedures.

The following operation and procedures should be carefully checked:

(a) cable pulling, splicing IR checking and terminating;

(b) cable segregation and separation;

(c) earthing of equipment and discharge clearance, earthing pits and conductors;

(d) identification of items, such as by coding, colouring and tagging;

(e) installation and connection of hydraulic, pneumatic and vacuum systems;

(f) installation of electric and instrumentation penetration assemblies;

(g) installation of protective devices against fire, such as fire stops and barriers; and

(h) location of safety/protection instruments.

III.3.1 Inspections to Verify Correctness of Installation

Inspections should be made to verify that equipment is located, installed, assembled and connected in compliance with specified requirements. Such inspections should include as appropriate, verification of:

(a) levelling and alignment;

(b) clearances and tolerances;

(c) proper location and routing of cables and sensing lines;

(d) tightness of connections and fastenings;

(e) freedom of moving parts;

(f) correct polarity;

(g) proper grounding and shielding;

(h) terminations;

(i) fluid levels and pressures;

(j) absence of leaks;

(k) physical integrity;

(l) identifying marks;

(m) accessibility for inspection and maintenance; and

(n) access for cooling air.

Inspections should be made to verify adequacy of measures employed during construction for preservation of systems pending their use or re-use. All temporary connections, such as jumpers and bypass lines and all temporary set points of control equipment, should be clearly identified and documented so that restoration to original conditions can be ensured before the item is placed in service.

III.3.2 Tests

Verification of construction activities should include tests to ensure that items being installed comply with specified quality and performance requirements. These tests should be performed at appropriate points in the construction phase. Where preliminary operation of equipment, during

construction, is utilised for a testing function, the purpose of the test, its scope, the conditions under which it is performed and its results should be clearly established and documented.

Tests should be repeated as appropriate if subsequent construction or associated activity may have affected their results. Repetition, if necessary, should be accomplished prior to commissioning.

Electrical, mechanical, physical and chemical tests should be performed during construction.

III.3.2.1 Electrical Tests

The following electrical tests should be performed:

(a) tests to ascertain circuit continuity, absence of short circuits, correct polarity and correct direction of rotation;

(b) tests to ascertain proper functioning of systems, including indicating meters, recorders, transducers, targets and lamps, annunciators and alarms, controls and interlocks;

(c) voltage breakdown tests on liquid insulation;

(d) overpotential tests as specified;

(e) measurements of insulation resistance, as specified; and

(g) earthing resistance.

When overpotential tests are performed, the values should conform to the applicable codes and standards.

III.3.2.2 Mechanical Tests

Appropriate mechanical tests should be performed to ensure that electrical or instrumentation components or systems can withstand rated pressures. These tests should be applied to pressure sensing and transmitting devices which operate in steam; to hydraulic, pneumatic and vacuum systems; to interconnecting tubing; and to associated instruments. Tests should be in accordance with applicable codes, procedures and standards,

and should be conducted after the assembly is completed.

III.3.2.3 Physical and Chemical Tests

Physical and chemical tests should include, as appropriate:

(a) Radiation testing, to confirm that radiation sensors and controlling devices function properly; and

(b) chemical analysis of fluids for purity, or for content of impurities such as oxygen or water.

ANNEXURE-IV

TYPICAL GRADED CLASSIFICATION OF QA LEVELS FOR CONSTRUCTION

IV.1 Typical Quality Assurance Levels

Typically four quality assurance levels are assigned as explained hereunder.

IV.2 Criteria in Selecting QA Levels:

The criterion to be used in establishing different QA levels are function of the item or service in terms of safety and operational importance, the complexity of construction process and the maturity of construction technology.

IV.2.1 QA Level-I is selected when,

(i) the item is intended for a critical application and there would be an undue risk to the health and safety of operating personnel and public, should a failure and malfunctioning occur; or

(ii) the items or services require a large number of complex construction processes; or

(iii) the items have a large number of close tolerances or moving parts; or

(iv) the construction-processes are new; or

(v) the contractor has little experience in the field.

IV.2.2 QA Level-II is used in the case of,

(i) the criticality of application;

(ii) importance of malfunction;

(iii) construction complexity and maturity of technology; and

(iv) are of intermediate degree, or the contractor has average experience.

IV.2.3 QA Level-III is selected when,

(i) the application is non-critical and there is no risk to the health and safety of operating personnel or the public should a failure or malfunction occur; or

(ii) the items or services require only a simple construction-processes, or

(iii) the items or services have few close tolerances and moving parts, or

(iv) the technology is proven, or

(v) the contractor is experienced in the field.

IV.2.4 QA Level-IV

Applied to items of proven design or manufacture where the commercial implication of failure is small.

IV.3 Grading of QA Requirements

For each of the QA levels mentioned above and in each area, the QA requirements are graded as under:

Grade 1: requires that the defined QA requirements be implemented in full. It is the most stringent grade;

Grade 2: for the same QA requirements, grade 2 is less stringent than grade 1;

Grade 3: for the same QA requirements, grade 3 is the least stringent grade of all;

Grade 4: Good commercial practice is acceptable with no additional QA requirements to provide adequate confidence.

The above grading depicts varying degrees of control, verification, measurements and records and still maintain confidence that items or services satisfy given requirements for quality.

The following four tables (Table-IV, parts A to D) show graded QA requirements for construction.

TABLE IV.1: GRADED QA REQUIREMENTS
Part-A Construction

QA Requirements	QA Level		
	I	II	III
	QA Grade*		
Personnel training and qualification	1	2	3
General activities			
Engineering	1	1	-
Planning	1	1	-
Preparation of procedures, instructions and drawings (including as built and updated drawings)	1	1	-
Housekeeping during construction and installation	1	2	-
Receiving, handling and storage of materials and equipment	1	1	3
Cleaning of fluid systems and associated equipment	1	2	-
Protective coating control	1	2	-
Measuring and test equipment control	1	1	3
Installation, inspection and testing of soil, foundations, concrete and structural steel			
Pre-construction verification	1	2	-
In-process inspection and test	1	1	3
Final inspection	1	2	3
Installation, inspection and test of equipment and systems			
Pre-installation verification	1	2	-
In-process inspection and test	1	1	3
Final inspection and test 1	2	3	
Analysis and evaluation of inspection and test results	1	2	-
Non-conformance control			
Identification and documentation	1	1	3
Segregation	1	1	3
Review and disposition	1	1	3
Integrated verification of completed systems	1	2	3

* For more detailed guidance on Grading, refer IAEA Technical Report Series No.328.

TABLE IV.1: GRADED QA REQUIREMENTS (continued)
Part-B Design

QA Requirements	QA Level		
	I	II	III
	QA Grade		
Personnel training and qualification	1	2	3
Design Process			
Specification of design input	1	2	-
Checking and approval of design input	1	-	-
Design process planning and performance	1	1	3
Design analyses	1	1	3
Drawing preparation	1	2	-
Preparation of specifications and other design documents	1	2	-
Design interface control during design process	1	1	-
Communication between design organisation and other organisations (feedback)	1	1	-
Design verification			
Design reviews and/or	1	2	3
Alternative calculations and/or	1	2	3
Qualification testing	1	2	3
Document control			
Document preparation, review and approval	1	1	3
Document release and distribution	1	1	3
Document change control	1	1	3
Control of design changes	1	2	-

TABLE IV.1: GRADED QA REQUIREMENTS (continued)
Part-C Procurement

QA Requirements	QA Level		
	I	II	III
	QA Grade		
Procurement documents, bids evaluation and award			
Personnel training and qualification	1	2	3
Planning for procurement	1	1	-
Procurement document preparation review and change control	1	2	3
Content of procurement documents	1	2	3
Procurement document control	1	1	-
Selection of procurement sources	1	2	3
Review of past performance	1	2	-
Evaluation of facilities and personnel	1	2	-
Evaluation of quality assurance programme	1	2	3
Bid evaluation and award	1	2	-
Purchaser evaluation of supplier performance			
Responsibility assignment	1	2	3
Purchaser and supplier co-ordination	1	2	3
Control of supplier generated documents	1	2	-
Control of changes in procurement documents	1	2	-
Verification activities by purchaser			
Planning of verification activities (procedure)	1	2	-
Planning of verification activities (responsibility assignment)	1	-	-
Implementation of verification activities	1	2	-
Reporting of verification activities	1	1	-
Non-conformance review and disposition	**1**	**2**	**3**
Corrective action	1	2	-
Acceptance of items and services	1	2	3

TABLE IV.1: GRADED QA REQUIREMENTS (continued)
Part-D Management of Construction

QA Requirements	QA Level		
	I	II	III
	QA Grade		
Personnel training and qualification	1	2	3
Planning and designing QA programme	1	1	-
Developing QA programme procedures	1	1	3
Documenting QA programme	1	1	3
Structuring the organisation	1	1	-
Documenting the organisation structure	1	1	3
Document control system	1	1	-
Preparation, review and approval of documents	1	1	-
Issue and distribution	1	1	-
Change control	1	1	-
Audits and reviews	1	2	-
Management reviews	1	2	-
Non-conformance control	1	1	1
Corrective action	1	2	-
Trend analysis	1	2	-
Reporting quality status	1	2	3
Reporting QA programme status and adequacy	1	1	-
Record management system	1	2	-

ANNEXURE-V(a)

TYPICAL LIST OF CONSTRUCTION PROCEDURES FOR MECHANICAL/ REACTOR/PIPING COMPONENTS

1. Optical alignment survey of embedded parts connected with reactor component erection.
2. Optical alignment procedure for reactor components.
3. Erection procedure for reactor components such as end shields, calandria/ coolant tubes, end fitting, reactivity mechanism, fuelling machines, fuel transfer components, etc..
4. Procedure for testing of valves in valve testing facility before their installation.
5. Erection procedure of stationary/rotating equipment.
6. Procedure for equipment/material handling.
7. Cleaning procedure for equipment/material, i.e., degreasing, wire brush cleaning, acid pickling, DM water wash, passivation. etc..
8. Procedure for sand/grit blasting, painting, metallising, galvanising, etc.
9. Bending procedure for pipes/tubes.
10. Wrapping and coating procedures for underground piping/equipment.
11. Piping/equipment hanger and support fabrication/erection procedure.
12. Procedure for installation of anchor fasteners.
13. Procedure for thermal insulation of piping/equipment.
14. Inert gas welding dam control procedure.
15. Erection procedure for piping and its component.
16. Crane testing procedures.

ANNEXURE-V(b)

TYPICAL LIST OF CONSTRUCTION PROCEDURES FOR INSTRUMENTATION COMPONENTS

1. Copper/stainless steel tubing erection procedure.
2. Procedure for erection/termination of control cables.
3. Procedure for erection of instruments, panels, etc..
4. Instrumentation tube joining procedure, i.e., flareless/compression type fitting joints, etc..
5. Automatic tube welding procedure.
6. Procedure for storage of radiographs.

ANNEXURE-V(c)

TYPICAL LIST OF CONSTRUCTION PROCEDURES FOR ELECTRICAL COMPONENTS

1. Earthing and lightening protection procedure.

2. Cable laying procedure, i.e., separation, termination sealing, fire barrier, glanding, etc..

3. Cable splicing procedure.

4. Erection procedure for transformers.

5. Erection procedure for electrical motors.

6. Erection procedure for switch gears.

7. Erection procedure for batteries.

8. Erection procedure for circuit breakers.

9. Erection procedure for isolators.

10. Erection procedure for electrical panels.

11. Relay testing procedure.

12. Procedure for containment wall cable penetration sealing and testing.

13. Pre-commissioning check of electrical/equipment and accessories.

ANNEXURE-V(d)

TYPICAL LIST OF CONSTRUCTION PROCEDURES FOR CIVIL WORKS

1. Soil/foundation investigation procedure.
2. Rock blasting procedure.
3. Geological investigation/foundation mapping procedure.
4. Procedure for testing of concrete ingredients.
5. Concrete mix design procedures.
6. Concrete preparation procedures.
7. Concrete testing procedures.
8. Concrete transportation and placement procedure.
9. Green cutting procedure.
10. Concrete curing procedures.
11. Concrete repair procedures.
12. Reinforcing bar splicing, bending and placing procedure.
13. Water stop control procedure.
14. Water proofing procedure.
15. Critical embedded part identification and placement procedure.
16. Post-concrete inspection procedure.

17. Pre-stressing procedure:

    17.1 Pre-qualification and testing during manufacturing of materials.

    17.2 Installation, post-tensioning and grouting procedure.

18. Caulking procedure for concrete joints.

19. Leakage and pressure testing of concrete pressure vessel and reactor building.

20. Procedure of fabrication of steel structures.

21. Procedure of erection (including high strength bolt joints) of structural steel.

22. Procedure of containment/reactor building painting.

ANNEXURE-V(e)

TYPICAL LIST OF PROCEDURES FOR QUALITY ASSURANCE AND PRE-SERVICE INSPECTION

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.

6. Various procedures for eddy current testing, (e.g. single frequency and double frequency EC 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 , HXs tubing, rolled joints, 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. Procedures for air hold test/pneumatic test of various systems.

15. Procedure for hydro tests.

16. Various welder qualification procedures and records.

17. Various welding procedures and their qualification records.

18. Still/video photography record of critical areas, e.g., calandria vault, etc..

19. Procedure for pre-service inspection and data collection for electrical/ instrumentation items as per station Technical Specification.

20. Pressure and leak testing of concrete pressure vessel and Reactor Building.

21. Internal QA Audit procedures.

22. Procedure for handling management instructions affecting quality.

ANNEXURE-V(f)

TYPICAL LIST OF GENERAL PROCEDURES FOR CONSTRUCTION

1. Access control procedure.
2. Organisation, authorisation and responsibility document.
3. QA Manuals.
4. Incoming material verification and inspection procedures.
5. Material/equipment storage/preservation — procedures.
6. Drawing/document control procedure.
7. Design change control procedures.
8. House-keeping and cleanliness control procedures.
9. Industrial safety procedures.
10. Work authorisation procedure.
11. Welding/brazing/soldering procedure for various applications.
12. Preheat and post-weld heat treatment procedure.
13. Welder/welding operator/brazer performance monitoring procedures.
14. Training and certification procedures for welders/welding operators, NDT personnel, tube rolling operators, etc.
15. Calibration of measuring and test equipment, including agencies for calibration.
16. Non conformance control procedures.

17. Testing procedure for material handling equipment, devices, e.g., cranes, chain-pulley blocks, etc..

18. As built drawing control procedure.

19. Construction completion document/system transfer document control procedures.

20. Procedure for combating emergencies; like plant fire, acts of nature (e.g. tornado, flood, earthquake, cyclone, storm etc.).

ANNEXURE-VI

TYPICAL LIST OF RECORDS AND THEIR RETENTION CATEGORIES

Sl.No.	Description	Permanent	Non-permanent
1.	**Receiving and Storage.**		
	Verification and inspection reports.		x
	Vendors history document and non conformance reports.	x	
	Storage, inventory and issuance reports.		x
	Periodic storage condition monitoring reports.		x
	Vendor quality assurance releases.		x
2.	**Civil**		
	Soil/foundation investigation reports.	x	
	Aggregate test reports.		x
	Batch plant operation report.		x
	Cement grab sample reports.		x
	Concrete cylinder test reports and charts.	x	
	Concrete design mix reports.	x	
	Concrete placement records.	x	
	Material property reports on containment liner and accessories.	x	
	Material property report on reinforcing steel/pre-stressing cables.	x	
	Material property and identification report on steel embedments in concrete.	x	

TYPICAL LIST OF RECORDS AND THEIR RETENTION CATEGORIES (continued)

Sl.No.	Description	Permanent	Non-permanent
2 (contd.)	Material property report on steel piling.	x	
	Material property report on structural steel and bolting.	x	
	Mix water chemical analysis.		x
	Pile drive log.	x	
	Pile loading test reports.	x	
	Containment vessel pressure proof test and leak rate test report and results.	x	
	Reinforcing steel splice and operator qualification reports.		x
	Releases to place concrete.		x
	Reports of high strength bolt tightening.		x
	Slump test results.		x
	Soil compaction test reports.	x	
	Water stop placement and joint inspection report.	x	
	Visual inspection of concrete finished joints and floor slope for draining, etc.		x
	Caulking/water proofing reports.	x	
	Pre-stressing/grouting reports.	x	
	Painting of concrete surfaces.		x

TYPICAL LIST OF RECORDS AND THEIR RETENTION CATEGORIES (continued)

Sl.No.	Description	Permanent	Non-permanent
3.	**Welding**		
	Weld fit-up and visual examination reports.		x
	Pre-heat and post-weld heat treatment records/graphs.		x
	Weld location diagrams.	x	
	Welding filler metal material reports.	x	
	Welding procedure/personnel qualification and performance monitoring.		x
	Liquid penetrant test final results.	x	
	Magnetic particle test final results.	x	
	Radiographic test final results	x	
	Ultrasonic test final results	x	
4.	**Mechanical/Reactor/Piping**		
	Foundation/reference point survey reports.		x
	Individual component physical identification, history document verification and corrective action if any before pre-assembly and erection.	x	
	Material property records.	x	
	Pre-assembly reports.	x	
	Component/system cleaning results/report.	x	
	Anchor fastener/foundation bolts reports.	x	
	Dimensional/alignment reports of equipment/piping/components etc.	x	

TYPICAL LIST OF RECORDS AND THEIR RETENTION CATEGORIES (continued)

Sl.No.	Description	Permanent	Non-permanent
4 (contd.)	Mechanical joint inspection report i.e., flange, screwed, etc.		x
	Surface preparation/painting.		x
	Hot/cold setting.	x	
	Grouting.	x	
	Erection report/route cards.	x	
	Pneumatic/vacuum box test results.	x	
	Hydro test results.	x	
	Helium leak test results.	x	
	Safety valve test results.	x	
	Pipe hanger and restraint data.	x	
	Lubrication records.		x
	Chemical composition for thermal insulation		x
	Chemical test of water used for mixing insulation cement.		x
	Thermal insulation erection report.		x
	Installed lifting and handling equipment inspection and test data.	x	
	Construction, lifting and handling equipment inspection and test data.		x
	Acceptance/release report at fabrication, pre-assembly, erection, pre-commissioning stages.		x

TYPICAL LIST OF RECORDS AND THEIR RETENTION CATEGORIES (continued)

Sl.No.	Description	Permanent	Non-permanent
5.	**Electrical, instrumentation and control**		
	Inspection reports of earthing/ lightning protection.	x	
	Cable laying reports i.e., separation, termination, sealing, fire barrier, glanding, etc.		x
	Certified cable test reports.	x	
	Reports of pre-installation tests.	x	
	Breakdown test of liquid insulation.	x	
	Erection reports for transformers motors, switchgears, batteries, circuit breakers, isolators, panels, JBs, instruments tubing,etc.	x	
	Mechanical joint inspection reports, i.e., flareless tube joint, screwed joint, etc.		x
	Instrument calibration results.		x
	Relay test results.	x	
	Pressure and leak testing of instruments, systems, cable seating in containment walls, etc.	x	
6.	**General**		
	Double door isolation air conditioning/ cleanliness of work area/access control.		x
	As-built drawings.	x	
	Calibration reports of measuring and test instruments and equipment.		x

TYPICAL LIST OF RECORDS AND THEIR RETENTION CATEGORIES (continued)

Sl.No.	Description	Permanent	Non-permanent
6 (contd.)	Certificate of qualification of inspection and test personnel, special process operators, etc.		x
	Field audit reports.		x
	Final inspection reports.	x	
	Non-conformance reports.	x	
	Special tool calibration records.	x	
	Specification and drawings.	x	
	Construction completion/ system transfer documents.	x	
	All procedures listed in Annexures-I to VI.	x	
	Boxing-up report of installed component to avoid contamination during further activities.		x
	Report of periodic inspection to monitor condition of erected components.		x
	Tagging of components.		x

ANNEXURE-VII

TYPICAL LIST OF DOCUMENTS TO BE GENERATED DURING ERECTION OF MAIN COMPONENTS OF TURBINE AND GENERATOR

1. Foundation, anchor bolt, reference point location and levelling survey report before and after concreting.

2. Checking and centering of seating plates with reference to scribe lines, dry packing and sound test.

3. Erection procedures and QA plans.

4. Individual component physical identification, history document verification and corrective action if any before installation.

5. Placement of main components like cylinders, diaphragms, gland, bearing housing, etc., and their centering with reference to centerline.

6. Placement of cylinder, bearings, and rotors as per catenary and their alignment.

7. Reaming, honing and coupling of rotors and their concentricity checks.

8. Bedding/blue matching of load-bearing surfaces like seating plates, bearings, palm keys, pedestals, etc..

9. Setting of thermal, steam/fluid path clearances between stationary and rotating parts.

10. Records of hot and cold setting of supports/parts like loop pipes and governor valves.

11. Checking of free movement/restraint of sliding supports/parts and bearings.

12. Record of various clearances during assembly.

13. Welding and preheat/post-weld heat treatment records.

14. Non-destructive testing reports.

15. Reference dimensions and levelling data reports after erection of critical parts like level of TG rotor journals, and distance of rotor collar with stationary pedestals.

16. Surface checking of piping flange joint and uniform tightening.

17. Setting of bellows and spring supports.

18. Record of final bolt extensions after heat tightening, locking and dowelling.

19. Checking of available float between stationary and rotating assembly after erection of complete assembly.

20. Removal of all foreign materials, final cleaning and boxing up of turbine and generator,

21. Arrangement of preservation like application of rust prevention during erection, e.g. rotors.

22. Insulation resistance and other electrical test report for generator during and after erection.

23. Purge test of generator rotor ventilation tunnels and generator casing air hold test report.

24. Thermal insulation report.

ANNEXURE-VIII(a)

TYPICAL QA CHECK LIST FOR PRE-ASSEMBLY OF COOLANT CHANNEL END FITTINGS

Sl.No.	Characteristic	Type of check	Instrument	Quantum/ frequency of check	Responsible agency* for checking and extent of examination		
					First Agency	Second Agency	Third Agency
	Pre-Requisites						
1.	Clean room condition is to be established and maintained during pre-assembly works	Visual	Wet Cloths Swab	Everyday	100%	100%	100%
2.	Procedure and operator are to be qualified for shrink measurement, fitting and liner tube leak test, rolling visual	Mech-anical	Micro-meter	100%	100%	100%	100%
	Decreasing						
3.	Check temperature of degreasing bath	Temp-erature measure-ment	Therm-ometer	Everyday	100%	100%	100%
4.	Conduct visual exami-nation of all compo-nents after degreasing. Pay special attention on critical surface	Visual	Magni-fying glass of max. 10 mag.	100%	100%	100%	100%

* First Agency - Contractor, Second Agency - Erection group of construction organisation(CO) Third Agency- Inspection group of construction organisation

TYPICAL QA CHECK LIST FOR PRE-ASSEMBLY OF COOLANT CHANNEL END FITTINGS (continued)

Sl.No.	Characteristic	Type of check	Instrument	Quantum/ frequency of check	Responsible agency* for checking and extent of examination		
					First Agency	Second Agency	Third Agency
	Shrink Fitting						
5.	Check End-fitting DCR and Shrink fitting ring dimensional report for any special components and remarks	Verifi-cation	—	100%	100%	100%	100%
6.	Check interference and record	Mecha-nical measure-ment	O.D. Micro-meter and bore dia gauge	100%	100%	100%	100%
7.	Check temperature of shrink fit ring	Tempe-rature measure-ment	Temp. stick	100%	100%	100%	100%
8.	Check for any gap between shrink fit face and dia D-9 collar of end-fitting	Mecha-nical measure-ment	Filler gauge	100%	100%	100%	100%
9.	Conduct air pressure test at 5 psi (g)	Pneu-matic test	Comp.air leak testing devices, soap solution, etc.	5%	100%	100%	100%

A TYPICAL QA CHECK LIST FOR PRE-ASSEMBLY OF COOLANT CHANNEL END FITTINGS (continued)

Sl.No.	Characteristic	Type of check	Instrument	Quantum/ frequency of check	Responsible agency* for checking and extent of examination		
					First Agency	Second Agency	Third Agency
	Rolling						
10.	Check DCRs of End-fitting and liner tube	Verification	—	100%	100%	100%	100%
11.	Check end fitting cleanliness and examination of all critical surfaces	Visual	Torch light & magnifying glass	100%	100%	100%	100%
12.	Check orientation of the end fitting	Mechanical measurement	Clenometer	100%	100%	100%	100%
13.	Take full length of the end-fitting, Dimension and coolant tube rolling area I.D and note gauge group number	Mechanical measurement	Stick micrometer bore dia	100%	100%	100%	100%
14.	Identify end-fitting group (I or II) orientation	Verification	—	100%	100%	100%	100%
15.	Check liner tube holding and drain hole locating tool	Mechanical measurement	Tape	Everyday	100%	100%	100%
16.	Pass go gauge before and after installing spacer buttons	Mechanical measurement	Go gauge	100%	100%	100%	100%

TYPICAL QA CHECK LIST FOR PRE-ASSEMBLY OF COOLANT CHANNEL END FITTINGS (continued)

Sl.No.	Characteristic	Type of check	Instrument	Quantum/ frequency of check	Responsible agency* for checking and extent of examination		
					First Agency	Second Agency	Third Agency
17.	Ensure coolant tube rolling area protective sleeve and closure seal face area protective sleeve are placed before engaging expander	Visual	—	100%	100%	100%	100%
18.	Witness expander setting and rolling	Visual	—	100%	100%	100%	100%
19.	Record spring back and check percentage wall reduction	Mechanical measurement	Bore diagauge	100%	100%	100%	100%
20.	Check orientation of end-fitting after rolling	Mechanical	Clenometer	100%	100%	100%	100%
21.	Check for cleanliness after rolling	Visual	—	100%	100%	100%	100%
22.	Check for cleanliness of split sleeves, journal rings, retaining ring and check S.R's and inspection reports	Visual	—	100%	100%	100%	100%
23.	Check peening of split sleeve screws after tightening	Visual	—	100%	100%	100%	100%
24.	Check packing of preassembled end fitting in polyethylene bag.	Visual	—	100%	100%	100%	100%

ANNEXURE-VIII(b)

TYPICAL QA CHECK LIST FOR FUELLING MACHINE CONTROL COMPONENT ERECTION

Sl.No.	Characteristic	Type of check	Instrument	Quantum/ frequenc of check	Responsible agency* for checking and extent of examination		
					First Agency	Second Agency	Third Agency
1.	Installation of panels and junction boxes	Identification of panels/JBs and location. Alignment	Measuring tape visual plumb - bob	100%	100%	100%	50%
2.	Installation of instru-ments in the panels and field	Identification of instrument and location orientation maintainability	Visual	100%	100%	100%	50%
3.	Laying of cables and glanding	Identification of cables and cable routing. Dressing and clamping continuity tester tightness of glands tagging	Visual continuity tester/ multimeter spanners	100%	100%	100%	100% (glan-ding) 50% (others)
4.	Termination of wires	Identification of terminal points,e.g. colour code, wire no. sleeving. dressing of wires type of termination (screwed/ soldered/ termigum) continuity check after termination.	Visual torque range screw driver continuity tester/ multimeter	100%	100%	100%	100%

TYPICAL QA CHECK LIST FOR FUELLING MACHINE CONTROL COMPONENT ERECTION (continued)

Sl.No.	Characteristic	Type of check	Instrument	Quantum/ frequency of check	Responsible agency* for checking and extent of examination		
					First Agency	Second Agency	Third Agency
5.	Laying of tubing and termination	Cleanliness and inspection of inside/ outside surface Preparation for joint maintainability of mechanical tube joint operatort qualification auto weld machine parameters pressure and leak testing tagging of tubes.	Visual lintfree cloth nylon wire Mirror magnifying lens comp-ressed air vernier caliper hread gauges go/no go gauges for flareless tube joint	100%	100%	100%	100%

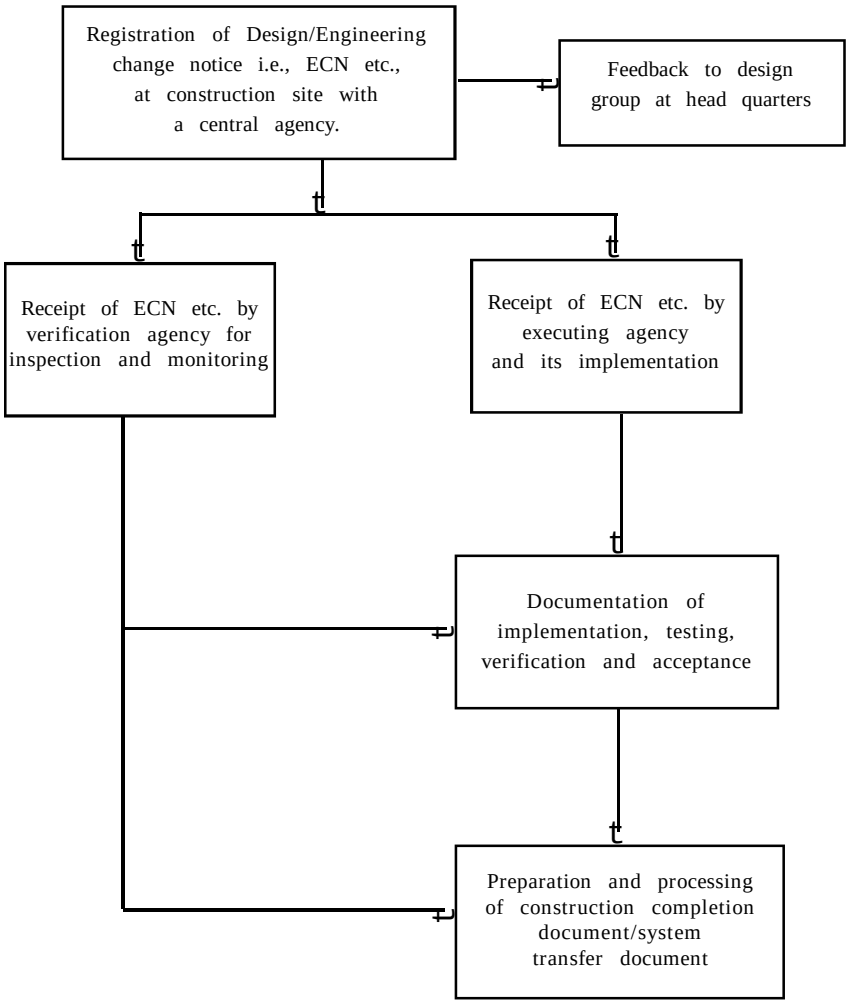
ANNEXURE-VIII(c)

TYPICAL QA CHECKLIST FOR ERECTION OF STATION CLASS-I POWER SUPPLY LEAD ACID BATTERIES

Sl.No.	Characteristic	Type of check	Instrument	Quantum/ frequency of check	Responsible agency* for checking and extent of examination		
					First Agency	Second Agency	Third Agency
1.	Foundation structure (check alignment, welding and anchor bolts)	Visual liquid penetrant examination measurement	Measuring Tape spirit level	100%	100%	50%	50%
2.	Battery stand assembly (check welding, alignment, wooden board stability, bolting, painting, grounding of stands, etc)	Visual measurement	Tape wrench paint thickness gauge	100%	100%	50%	50%
3.	Erection of cells (check, identification, alignment, cleanliness, assembly, connections, contact surface resistance, glanding, etc)	Visual measurements	Torque wrench multimeter kelvin Bridge megger tape	100%	100%	100%	100%
4.	Battery room ventilation fans operability, availability of hydrogen detectors	Visual and functional	—	100%	100%	100%	100%
5.	Acid filling (check specific gravity, level, etc.)	Visual measurements	Hydrometer	100%	100%	100%	100%
6.	Pre-commissioning						
a.	First charging and C-10 test:- Check - cell voltage, specific gravity of electrolyte, battery voltage and current during count down every half an hour.	Visual measurement	Battery check voltmeter ammeter hydrometer watch	100%	100%	100%	100%
b.	Second charging and C - 1/2 test :- check - cell voltage, specific gravity, battery voltage and current during count down every 5 minutes.	Visual measurement	Battery check voltmeter ammeter hydrometer watch	100%	100%	100%	100%

ANNEXURE-IX

TYPICAL FLOWCHART TO CONTROL DESIGN/ENGINEERING CHANGES



ANNEXURE-X

TYPICAL LIST OF STAGES/ACTIVITIES FOR AUDIT/ASSESSMENT

Sl.No.	Stages/Activities
	General
1.	Material/equipment storage facility before receipt of safety-related equipment/components. Periodic monitoring of storage condition.
2.	Availability of testing and calibration facilities, qualified manpower, procedures, QA manuals, etc., before start of activities.
3.	Cleanliness in field before start of erection of reactor components, piping, etc.
4.	Periodic review of document generation, registration, processing and storage i.e., test reports, procedures, non-conformance control, construction completion certificates, etc.,
5.	Periodic review of protection of installed equipment/piping/cable, tubing, anchor bolts, etc,
	Civil
1.	Before start of concreting of foundation.
2.	During and after completion of concreting of the following: (a) suppression pool, (b) calandria vault, (c) containment walls, (d) spent fuel storage bay, (e) TG - foundation.
3.	During and after completion of pre stressing
4.	During and after completion of erection of main structural steel in reactor building.
5.	Before start of integrated leak rate test of containment

TYPICAL LIST OF STAGES/ACTIVITIES FOR AUDIT/ASSESSMENT
(continued)

Sl.No.	Stages/Activities
6.	Water proofing/leak tightness of trenches, tunnels, etc., of complete plant to avoid flooding of main plant. Periodic review during and after completion of work.
	Reactor, Piping, Mechanical
1.	Before start and after completion of erection of the following reactor erection activities: (i) calandria - end shield alignment and welding; (ii) pre-assembly of reactor components; (iii) calandria tubing; (iv) coolant channel; (v) reactivity mechanism; and (vi) fuelling machine and fuel transfer equipment.
2.1	Before and after completion of erection of following activities of piping, etc: (i) feeders, headers, PHT pumps, (ii) steam generators.
2.2.	Before hydrostatic testing of: (i) PHT System; (ii) moderator system; (iii) fuel transfer system; and (iv) steam and feed water system.
2.3	After completion of erection of hanger and supports of PHT, moderator system, fuel transfer system, steam lines, feed water system, etc.
3.	Checking of documentation of completion of construction and testing, physical condition of installed components, cleanliness, removal of foreign material, passivation, surface protection, etc., before boxing up of the following:

TYPICAL LIST OF STAGES/ACTIVITIES FOR AUDIT/ASSESSMENT
(continued)

Sl.No.	Stages/Activities
	(i) calandria; (ii) calandria vault before filling water; (iii) steam generators before closing man hole/hand hole; (iv) suppression pool before filling water; (v) any other equipment which was opened at site; and (vi) turbine/generator
	Electrical
1.	Before energisation of 6.6 kV switchgear, 415V switchgear and 415V MCC, 230V class-II power supply including battery, control UPS, DCDB and power UPS.
2.	Before commissioning of emergency diesel generator.
3.	During laying of safety-related cables and after completion of complete fire barrier protection system.
4.	During laying of earthing and lightning protection system.
5.	After erection and testing of cable penetration box EPS and cable penetration assembly sealing for reactor building containment isolation.
	Instrumentation
1.	After completion of junction box erection and cable laying in control room, channel room and CDF room.
2.	After erection of instrumentation work on DNM, CTM, CFM, moderator system, secondary shutdown system, ALPAS, GRAB and ECC systems.
3.	After erection of reactivity mechanisms.
4.	After erection of CRCS/PDCS in control room.
5.	During instrumentation tube welding and flareless tube joint erection.

ANNEXURE-XI

TYPICAL QUALITY ASSURANCE AUDIT CHECKLIST

(i) Audit :

(ii) Activity : Quality assurance of instrumentation and control erection activities

(iii) Applicable Requirement and Programme:
(1) QA Manual of project and various contractors
(2) Technical specifications and tender documents

(iv) Checklist :

Sl.No.	Item	Observation
1.	**Organisation:**	
1.1	Whether well-defined organisation chart of project/contractors is available	
1.2	Whether QA is sufficiently independent and reports to top management	
1.3	Whether tender document specifies independent quality control and inspection set up with the contractor	
1.4	Whether independent QC & I section is available with contractor	
2.	**QA Programme**	
2.1	Whether QA plans are available for all activities with all agencies.	
2.2	Whether contractor has provision for review of QA programme, frequency thereof, follow-up action and record thereof.	

TYPICAL QUALITY ASSURANCE AUDIT CHECKLIST (continued)

Sl.No.	Item	Observation
2.3	Whether there is a procedure for generation, identification, distribution and maintenance of QA records.	
3	Planning and documentation of activities	
4	Qualification and training of personnel	
5	Procedure, instruction and drawings	
6	Control of drawings/specification	
7	Procurement	
8	Measuring and test equipment control	
9	Verification of construction, inspection/ test processes	
10	Inspection checklist/reports	
11	Non-conformance control	
12	Change control	

Note: Breakdown of checklist items from S.No.4. to 12. will be required.

ANNEXURE-XII

TYPICAL SUMMARY REPORT OF CHECKING (PHYSICAL/RECORDS) OF COMPLETENESS OF PIPING CIRCUIT BEFORE PRESSURE AND LEAK TESTING

Sl.No.	Description of work	Total No.	Individual inspection report availability	Availability of consolidated completion report (listing item of work and report No.)	Physical checking done and found complete and acceptable	Record checking done and found complete and acceptable	Availability of as-built drawing	Remarks
1	2	3	4	5	6	7	8	9
1.	Pipe/tube welds							
2.	Flange joints							
3.	Threaded joints							
4.	Flareless tube fitting joints							
5.	Pipe/tube bend							
6.	Hanger and supports							
7.	Pipeline erection							
8.	Equipment/ instrument erection							
9.	Piping colour code							
10.	Numbering of pipelines							

Authorised by:

(Verification Agency)

ANNEXURE-XIII

TYPICAL CHECKLIST FOR INTEGRATED VERIFICATION OF COMPLETION OF CONSTRUCTION OF SYSTEMS

(i) Unit No. :

(ii) Code No., i.e., USI No. etc. :

(iii) System description :

(iv) Documents required :

1. Marked up flow sheets of piping/instrumentation system testing.
2. Piping/instrumentation tubing circuit testing procedures.
3. Summary acceptance report of completeness checking of piping/instrumentation tubing circuits before pressure and leak testing.
4. Pressure/leak test reports of circuits.
5. Summary acceptance and field survey report of hanger, supports and snubbers.
6. Summary acceptance and field survey report of insulation/ painting/protective coating.
7. Summary acceptance and field survey report of checking of completeness of cable laying, termination, etc.
8. Summary acceptance and field survey report of fire barriers.
9. Summary acceptance and field survey reports of other activities covered in the checklist.
10. Construction completion certificates.
11. Equipment details.

(v) Check list

TYPICAL CHECKLIST FOR INTEGRATED VERIFICATION OF COMPLETION OF CONSTRUCTION OF SYSTEMS (continued)

Sl.No.	Description of activity/work	Total no. of reports/ certificates	Remarks about acceptance, etc.
1.	**Piping and Associated Component Erection**		
1.1	Pressure/leak testing		
1.1.1	Hydrostatic pressure test acceptance report of circuits/components.		
1.1.2	Pneumatic test acceptance report of circuits/components.		
1.1.3	Helium leak test acceptance report of circuits/components.		
1.2	Equipment/instrument/valve/ component/pipeline,etc. erection.		
	Field survey and acceptance report (also check for direction of flow, elevation of tapping, etc.)		
1.3	Hanger, supports and snubbers		
	Field survey and acceptance reports.		
1.4	Report of survey in the field for restraint/free movement provisions of equipment, pipe lines, supports, etc.		
1.5	Acceptance report of safety devices, i.e., safety valves, rupture discs, etc.		
1.6	Report of survey in the field for:		
	(a) maintainability,		
	(b) ease of operation,		
	(c) in-service inspection.		

TYPICAL CHECKLIST FOR INTEGRATED VERIFICATION OF COMPLETION OF CONSTRUCTION OF SYSTEMS (continued)

Sl.No.	Description of activity/work	Total no. of reports/ certificates	Remarks about acceptance, etc.
1.7	Field survey and acceptance report of cleanness and passivation of erected stainless steel piping, tanks, components, etc.		
1.8	Piping/equipment-insulation Field survey and acceptance report.		
2.	**Instrumentation and Associated Component Erection**		
2.1	Pressure and leak testing		
2.1.1	Hydrostatic pressure test acceptance report of circuits/components.		
2.1.2	Pneumatic test acceptance report of circuits/components.		
2.1.3	Helium leak test acceptance report of circuits/components.		
2.2	Instrument/component, etc., erection and mounting Field survey and acceptance report. (also check for direction of flow, elevation of tapping for LS/LT, Beetles w.r.t. floor slopes, etc.)		
2.3	Hanger and supports Field survey and acceptance report.		
2.4	Acceptance report of safety devices e.g. safety valves, instrument relief valve, rupture discs, etc.		

TYPICAL CHECKLIST FOR INTEGRATED VERIFICATION OF COMPLETION OF CONSTRUCTION OF SYSTEMS (continued)

Sl.No.	Description of activity/work	Total no. of reports/ certificates	Remarks about acceptance, etc.
2.5	Cables Field survey and acceptance report of cable laying and dressing (check for termination, identification, designated location, sealing of JBS, penetration through reactor building containment, etc.)		
2.6	Report of survey in the field for: (a) maintainability (b) ease of operation (c) inservice Inspection		
2.7	Field survey and acceptance report of cleanness and passivation of stainless steel tubing, tanks, components.		
3.	**Reactor/Mechanical-Equipment and Associated Component Erection**		
3.1	Pressure and leak testing		
3.1.1	Hydrostatic testing of equipment/components		
3.1.2	Pneumatic testing of equipment/components		
3.1.3	Helium leak testing of equipment/components		
3.2	Equipment/Component erection Field survey and acceptance report (also check for restraint/ free movement provisions, etc)		

TYPICAL CHECKLIST FOR INTEGRATED VERIFICATION OF COMPLETION OF CONSTRUCTION OF SYSTEMS (continued)

Sl.No.	Description of activity/work	Total no. of reports/ certificates	Remarks about acceptance, etc.
3.3	Hanger, support and snubbers Field survey and acceptance report (Also check for restraint/free movement provisions, load distribution, etc.)		
3.4	Acceptance report of safety devices, e.g., safety valves rupture disc, etc.		
3.5	Report of survey in the field for: a) maintainability b) ease of operation c) inservice Inspection		
3.6	Field survey and acceptance report of cleanness and passivation of erected stainless steel components.		
3.7	Equipment/component insulation Field survey and acceptance report.		
4.	**Electrical and Associated Components Erection**		
4.1	Pressure and leak testing acceptance report of components		
4.2	Equipment and component Erection Field survey and acceptance report (also check for restraint/ free movement provisions,etc.)		
4.3	Acceptance report of safety devices, protective devices including fire fighting systems (LTG protection panels switchgears, MCCs, etc. Also check for burnt oil/soak pit of transformer, earthing, etc.)		

TYPICAL CHECKLIST FOR INTEGRATED VERIFICATION OF COMPLETION OF CONSTRUCTION OF SYSTEMS (continued)

Sl.No.	Description of activity/work	Total no. of reports/ certificates	Remarks about acceptance, etc.
4.4	Hanger/supports/cable trays Field survey and acceptance report (also check for cable tray earthing, tray identification, etc.)		
4.5	Cables Field survey and acceptance report of cable laying, and dressing (check for termination, identification, designated location, sealing at JBs, penetration through reactor building containment, etc.)		
4.6	Field survey and acceptance report of plant earthing and lightning protection.		
4.7	Report of survey in the field for: (a) maintainability (b) ease of operation (c) inservice Inspection		
4.8	Field survey and acceptance report of fire barriers		
5.	**Civil Works**		
5.1	Field survey for completion of all civil work		
5.2	Field survey for condition of floor drains/slope, etc., to avoid water logging.		

TYPICAL CHECKLIST FOR INTEGRATED VERIFICATION OF COMPLETION OF CONSTRUCTION OF SYSTEMS (continued)

Sl.No.	Description of activity/work	Total no. of reports/ certificates	Remarks about acceptance, etc.
5.3	Field survey and acceptance of: (a) Pipe/cable trench/tunnel water leak tightness (b) Pipe/cable trench/tunnel sealing to avoid flooding of buildings (specially check all penetrations below basement) (c) Dewatering arrangements		
5.4	Adequacy of radiation shielding		
6.	**General**		
6.1	Design/engineering change control		
6.1.1	Acceptance report of implementation of ECNs, DCRs, etc.		
6.2	Availability of approach ladders/platforms		
6.3	Field survey and acceptance report of availability of tags/identification of equipment, pipeline, cables and trays,instruments, etc.		
6.4	Availability of: (a) as-built drawings (b) updated drawings		
6.5	Field survey and acceptance report of painting/protective coating of concrete surfaces, equipment, pipelines, structure, etc		

TYPICAL CHECKLIST FOR INTEGRATED VERIFICATION OF COMPLETION OF CONSTRUCTION OF SYSTEMS (continued)

Sl.No.	Description of activity/work	Total no. of reports/ certificates	Remarks about acceptance, etc.
6.6	Availability of pre-service inspection report of heat exchanger tubes, ultrasonic testing of welds, electrical/ instrumentation, etc., items as per ISI document		
6.7	Field survey and acceptance/ adequacy of : (a) permanent illumination in the areas as per design and industrial safety (b) ventilation (check for design flow, humidity requirement and temperature)		
6.8	Completion and acceptance of deficiency, if any, pointed out by internal/external audit.		
6.9	Summary report (including acceptance) of any rework/ repair/inspection of internals, etc., done at site on supplied equipment/ component.		
7.	Boxing-up report of equipment/ component/areas (i.e. calandria, calandria vault, steam generators, TG HXs, transformers,etc.)		
8.	Any other activity not covered above.		

Note: Reference numbers of the documents may be mentioned where necessary.

TYPICAL CHECKLIST FOR CALANDRIA BOXING UP FOR 220 MWe PHWR

Sl.No.	Description of activity/work	Total no. of reports/ certificates	Remarks about acceptance, etc.
1.	**Checking of records completion and verification of CCC for following works:** (a) Calandria end shield joint. (b) All pending works on calandria as per history docket. (c) Reactivity stand pipe welding. (d) Installation of internal of primary shut off guide tube, liquid poison tube, outflow tubes of reactivity mechanism. (e) All pipe connections to calandria nozzles.		
2.	**Physical checking** (a) Moderator inlet diffuser (calandria side welding). (b) Tack welding of upper sleeve of liquid shut-off location SSS) (c) Welding of male plug adapter of (PSS) (d) Welding of diffuser sleeve of reactivity mechanism location. (e) Welding of male plug adapter of flux mapping. (f) Final lateral clearance of guide tubes and flow tubes with calandria tubes. (g) Lateral swing of guide tubes and flow tubes.		
3.	**General examination:** (a) Cleanliness of inside surface of calandria.		

TYPICAL CHECKLIST FOR CALANDRIA BOXING UP FOR 220 MWe PHWR (continued)

Sl.No.	Check Point Activity	Agency	Remarks
	(b) Any physical damage on calandria tubes,guide tubes, etc. (c) Presence of rust spot or other stains. (d) Presence of any loose items in OPRD pipes, inside the vessel or any of the pipelines.		
4.	**Contamination check:**		
	(a) Ferrous contamination check on the inside surface of the calandria. (b) Chloride contamination check on the inside surface of the calandria.		
5.	**Final clearance:**		
	(a) Still photography of internals of calandria vessel. (b) Metal cover installation with locking arrangement for OPRD pipeline ends and upper stand pipe locations. (c) Presence of representatives for all groups connected with commissioning.		

6. Certification

The above points have been checked and vessel cleared for boxing up

Person checking the details	RE	Piping	QS&I	FE	Commissioning
Signature					
Name					
Designation					
Date					

ANNEXURE-XIV

TYPICAL CHECKLIST FOR CALANDRIA VAULT BOXING UP FOR 220 MWe PHWR

Sl.No.	Check Point Activity	Agency	Remarks
1.	**Checking of completeness and verification CCC's for following works:** (a) Moderator system piping, cover gas piping (b) Calandria vault cooling piping (c) Ion chamber assembly (d) Calandria/end shield assembly and calandria keys (e) Reactivity mechanism (f) Rehearsal test facility (g) Calandria vault liner welding and NDT on 3 Nos. closure plate on floor reference point location/ west wall opening. (h) Top hatch beams.		
2.	**Physical verifications:** (a) Moderator system piping (b) Calandria vault cooling piping/ cover gas piping (c) Ion chamber assembly (d) Calandria/end shield assembly and calandria key. (e) Reactivity mechanism (f) Rehearsal test facility (g) Calandria vault liner-welding and NDT on 3 Nos. closure plates on floor reference point locations/ east wall opening (h) Top hatch beams installation and sealing completeness		

TYPICAL CHECKLIST FOR CALANDRIA VAULT BOXING UP FOR 220 MWe PHWR (Continued)

Sl.No.	Check Point Activity	Agency	Remarks
3.	**Checking of all pipe supports, sealing bellows fasteners, etc. for proper installation/leaking of following systems:** (a) Moderator system, moderator cover gas system piping (b) Calandria vault cooling system (c) Ion chamber assembly (d) Calandria key structure (e) Rehearsal test facility		
4.	**Checking completeness and verification of following reports:** (a) Pneumatic, hydrostatic and helium leak testing on piping and vessel joints (b) Ultrasonic testing on pipe joints (PSI) (c) Checking of thickness by UT at the mismatch area on calandria end shield joints.		
5.	**Preparation for records:** (a) As-built drawing for welds (b) Video of calandria vault components (c) Still photographs of calandria vault components (d) 3-D coordinate measurement of joint location		

TYPICAL CHECKLIST FOR CALANDRIA VAULT BOXING UP FOR 220 MWe PHWR (continued)

Sl.No.	Check Point Activity	Agency	Remarks
6.	Clean and decontaminate the surfaces of CV liner, calandria vessel piping etc.:		
7.	Clean the space between ring shield and remove the asbestos rope wrapped around the ring shield:		
8.	Conduct decontamination check on cleaned surface:		
9.	Remove all loose material, scaffolding from vault (including cover and asbestos rope from SS bellows):		
10.	EP pipe penetration leak tightness check:		

11. Certification

The above points have been checked and vessel cleared for boxing up

Person checking the details	RE	Piping	QS&I	FE	Commissioning
Signature					
Name					
Designation					
Date					

LIST OF PARTICIPANTS

ADVISORY COMMITTEE ON CODES AND GUIDES FOR QUALITY ASSURANCE FOR NUCLEAR POWER PLANT (ACCGQA)

Dates of meetings:	March 24, 1995	November 27,1995
	April 28, 1995	August 31,1998
	May 26, 1995	September 1, 1998
	June 16, 1995	

Members and alternates participating in meetings:

Shri R.S. Kumar(Chairman)	:	Director, NPCIL (Formerly)
Shri M. Das	:	NPCIL
Shri N.V. Wagle	:	L&T
Shri M.S. Ghate	:	BARC
Shri S.P. Singh	:	AERB (Formerly)
Shri S.K. Warrier	:	AERB
Shri A.K. Asrani (Member-Secretary)	:	AERB
Smt. Usha A. Menon (Co-opted)	:	AERB
Shri R.C. Rawal* (Invitee)	:	NPCIL
Shri M.M. Lal (Invitee)	:	NPCIL

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* Author of the first draft of this Guide.

ADVISORY COMMITTEE ON NUCLEAR SAFETY (ACNS)

Date of meeting : July 22, 2000.

Members and alternates participating in the meeting:

Shri S.K. Mehta (Chairman)	: Director RG, BARC (Formerly)
Shri S.M.C. Pillai	: Nagarjuna Power Corporation, Hyderabad
Shri U.N. Gaitonde	: IIT, Bombay
Shri S.K. Goyal	: BHEL
Shri Ch. Surendar	: NPCIL
Dr. U.C. Mishra	: BARC
Shri S.K. Sharma	: BARC
Dr. V. Venkat Raj	: BARC
Shri S.P. Singh	: AERB (Formerly)
Shri G.K. De	: AERB (Formerly)
Shri R.S. Kumar (Invitee)	: Chairman, ACCGQA
Shri A.K. Asrani (Invitee)	: Member, ACCGQA
Dr. S.K. Srivastava (Invitee)	: NPCIL
Shri K. Srivasista (Member-Secretary)	: AERB

PROVISIONAL LIST OF CODE AND GUIDES ON QUALITY ASSURANCE

Safety Series Nos.	Provisional Title	Year of Publication
AERB/SC/QA	Code of Practice on Quality Assurance for Safety in Nuclear Power Plants.	1988
AERB/SG/QA-1	Quality Assurance in the Design of Nuclear Power Plants.	2001
AERB/SG/QA-2	Quality Assurance in Procurement of Items and Services for Nuclear Power Plants.	1998
AERB/SG/QA-3	Quality Assurance in the Manufacture of Items for Nuclear Power Plants.	1998
AERB/SG/QA-4	Quality Assurance During Site Construction of Nuclear Power Plants.	2001
AERB/SG/QA-5	Quality Assurance During Commissioning and Operation of Nuclear Power Plants.	1993
AERB/SG/QA-6	Assessment of the Implementation of the Quality Assurance Programme	To be issued.
AERB/SG/QA-7	Establishing and Implementing a Quality Assurance Programme	To be issued
AERB/SG/QA-8	Document Control and Records	To be issued

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