

**BHARATIYA NABHIKIYA VIDYUT NIGAM LIMITED**

**(A Government of India Enterprise)**

**KALPAKKAM 603 102**

**BHAVINI**

**PFBR**

**QUALITY ASSURANCE MANUAL**

**FOR**

**PROCUREMENT, MANUFACTURING  
&  
SITE CONSTRUCTION ACTIVITIES**

**REVISION NO.1**

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# BHARATIYA NABHIKIYA VIDYUT NIGAM LIMITED

(A Government of India Enterprise)

## KALPAKKAM 603 102

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### QUALITY ASSURANCE MANUAL FOR PROCUREMENT, MANUFACTURING & SITE CONSTRUCTION ACTIVITIES

	<b>Names</b>	<b>Date</b>	<b>Signature</b>
<b>Prepared by</b>	Shri. K. Gopal, SO/F, QA		
	Shri. G.V.V.S.R.Kishore SO/C, QA		
<b>Reviewed by</b>	Shri. S.S. Dhere, ACE (Civil)		
	Shri. V.K. Sethi, SO/H, Procurement (Mechanical).		
	Shri. K. Ganeshan, SO/F (Electrical)		
	Shri. A. Ananth, SO/E. (Instrumentation)		
	Shri. H.R. Sridhara, SO/E, (FE)		
	Shri. M. Krishna Rao. PE (SP)		
	Shri. M. Palaniappan, SO/H (QA)		
	Shri. S. Gurunathan, CE (QA)		
<b>Approved by</b>	Shri. Prabhat Kumar, Project Director, BHAVINI		
	Shri. R. Prabhakar, Director (Technical), BHAVINI		

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# **BHARATIYA NABHIKIYA VIDYUT NIGAM LIMITED**

**(A Government of India Enterprise)**

## **KALPAKKAM 603 102**

### **QUALITY POLICY**

Bharatiya Nabhikiya Vidyut Nigam Limited (BHAVINI) is committed to organize, provide and direct all its resources in establishing and maintaining an effective quality management programme and continually improving its effectiveness in implementation during the phases of construction of 500 MWe Prototype Fast Breeder Reactor project. Presently, the construction activities have been organized under two Directorates namely, Technical Directorate and Construction Directorate. These Directors directly report to CMD, BHAVINI.

Accordingly, two independent QA groups – QA (Procurement) under Director (Technical) and QA (Construction) under Project Director have been set up.

QA (P) is responsible for quality management during procurement and manufacturing of components and equipment at the manufacturers' shop and also works carried out at Site Assembly Shop.

QA (C) is responsible for quality management during construction at site. Both the QA groups shall function independently, but in close co-ordination to ensure the effectiveness.

All the components / equipment manufactured will be delivered to the concerned construction groups with relevant QA records. These will be reviewed by QA (C), thereby ensuring an independent verification of the QA requirements during procurement and

manufacturing. It also serves as an independent audit of QA during procurement and manufacturing.

Director (Technical) and Project Director have the responsibility for implementing the Quality Assurance programme for all the design inputs, procurement, manufacture and site construction activities of the Nuclear Power Plants under BHAVINI. This responsibility is delegated to heads of line function groups of various disciplines, and Heads of Quality Assurance Groups have the responsibility for formulating, reviewing, monitoring, verifying and assessing effectiveness of the Quality Assurance programme. Heads of the Quality Assurance Groups have also been delegated the authority for suspension of work in the event of significant deviations in quality related activities when noticed, till they are resolved.

DIRECTOR (TECHNICAL)

PROJECT DIRECTOR

## **CHAPTER - 1**

### **GENERAL ASPECTS**

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## **GENERAL ASPECTS**

### **1. 1. INTRODUCTION**

#### 1.1.1. SCOPE

Quality Assurance during construction constitutes a key element in the overall Quality Management System (QMS). This QA programme has been developed to meet the requirements of QMS document of BHAVINI, AERB Code of Practice on QA for Safety in Nuclear Power Plants AERB Code No.SC/QA/June 30, 1988. Provisions of AERB Safety Guide AERB-SG-QA-4, QA during Procurement, Manufacturing and Site Construction of Nuclear Power Plants have been addressed. The main objective of this QA programme is to ensure that all the activities are carried out in a systematic and planned manner and that the quality of work is according to approved specifications, drawings, codes and standards. Documented QA programme shall be established for all the activities of BHAVINI, such as design, procurement, manufacture, receiving, storing and preservation of the components, civil construction, cleaning, erection, installation, BoP (Mechanical Non Safety related) components, Piping, Mechanical, Electrical, Instrumentation & Control system works and inspection & testing of components and systems. Provisions shall be made for performance verification, review and audit of activities affecting quality. Technical requirements and other special administrative controls affecting quality shall be suitably stated in relevant work procedures and their implementation shall be ensured.

This QA manual is intended to provide a disciplined approach to all activities affecting quality, including verification, that each task has been satisfactorily performed and necessary corrective actions have been implemented. It is also intended to provide documentary evidence to demonstrate that the specified quality has been achieved.

#### 1.1.2. APPLICABILITY

This QA manual shall be applicable for the construction of safety and safety related and other structures and systems and the quality related elements identified and controlled through out the stages of construction of the plant, covering the following phases:

- a) Design as performed by Field Engineering (FE) Group
- b) Procurement
- c) Receiving, storage and handling

- d) Fabrication, cleaning, erection, installation and testing
- e) Pre-commissioning and
- f) Commissioning

Quality Assurance for design is not covered in this manual. The responsibility for the design of PFBR rests with Reactor Engineering Group (REG), IGCAR and the drawings and specification for all the main plant items shall be prepared, checked and approved by Reactor Engineering Group or their authorized consultants and shall be made available to the Field Engineering Group of Technical Directorate, BHAVINI for construction. For details of QA in design for PFBR, please refer "Quality Management System Manual (QMS Manual)" Document No. PFBR/01000/ML/1004 – Rev.0 – October 2003. After the drawings and specifications are received at PFBR site, FE group shall be responsible for the necessary changes / modifications in design and all design related issues such as disposition / approval of DCR/NCR and ECN, in consultation with REG, IGCAR.

All the groups involved in the construction activities shall ensure that the QA activities deployed on any item or service depend upon the factors such as safety classification, complexity, degree of standardization, quality history, accessibility for maintenance, inspection and replaceability of the item or service.

## **1.2. DEFINITIONS & ABBREVIATION**

### 1.2.1. DEFINITIONS

#### Acceptable Limits

Limits acceptable to AERB for Accident Conditions.

#### Accident conditions

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

#### Applicant

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

#### Approval

Formal consent to a proposal.

#### Atomic Energy Regulatory Board (AERB)

National authority designated by Government of India, assisted by technical and other advisory bodies, and having the legal authority for conducting the authorization process, for issuing authorization and thereby for regulating Nuclear Power Plant siting, construction, commissioning, operation and decommissioning or specific aspects thereof.

#### Audit

A documented activity performed to determine by investigation, examination and evaluation of Objective Evidence the adequacy of, and adherence to, established procedures, instructions, specification, codes, standards, administrative or operational programme and other applicable documents, and the effectiveness of implementation.

#### Authorization

The granting of written permission by AERB to perform specified activities

#### Commissioning

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

### Competent Authority

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

### Construction

The process of procurement, manufacturing and assembling the components of PFBR, 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 NPP is finally taken out of operation, which includes completion of de-fuelling of the core and associated activities.

### Design Input

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

### Design Interfaces

The boundary between the design-related responsibilities and activities of one organization, group or individual. It includes both the external design interface, which is the boundary between different organizations; and the internal design interface, which is the boundary between design units of the same organization.

### Design Output

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

### Disposition

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

### Documentation

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

### Emergency situation

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

### Examination

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

### Inspection

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

### Item

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

### Items Important to safety

The items which comprise:

- Those structures, systems and components whose malfunction or failure could lead to undue radiation exposure of the site personnel or members of the public.
- Those structures, systems and components which prevent anticipated operational occurrences from leading to Accident Conditions.
- Those features which are provided to mitigate the consequences of malfunction or failure of structures, systems or components.

### Non-Conformance

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

### Nuclear Power Plant

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

## Objective Evidence

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.

## Operation

All activities performed to achieve, in a safe manner, the purpose for which the plant was constructed, including maintenance, refueling, in-service inspection and other associated activities.

## Prescribed Limits

Limits established or accepted by AERB for operational states.

## Qualified Person

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

## Quality

The totality of features and characteristics of a product or service that bears 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.

## 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.

## Records

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

## Reliability

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

## Repair

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

## Responsible Organisation (RO)

The Organisation having over all responsibility for siting, design, construction, commissioning, operation and decommissioning the NPP .

## Rework

The process by which a non-conformance item is made to conform to a prior specified requirement by re-machining, re-assembling or other corrective means.

## Safety

Protection of all persons from undue radiological hazard.

## Safety Limits

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

## Safety Report

A document provided by the Responsible Organisation to AERB containing information concerning the PFBR, its design, accident analysis and provisions to minimize the risk to the public and to the site personnel.

## Safety Systems

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

## Services

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

## 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 NPP, defined by a boundary and under effective control of the Plant Management.

## Site Personnel

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

## Specification

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

## Supplier Evaluation

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

## Surveillance

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

## Technical Specification for Operation

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

## Verification

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

## 1.2.2. ABBREVIATIONS

AA	Authorized Agency
ACE	Additional Chief Engineer
AEC	Atomic Energy Commission
AERB	Atomic Energy Regulatory Board
ASME	American Society of Mechanical Engineers
ASNT	American Society for Non Destructive Testing
ASTM	American Society for Testing of Materials
BHAVINI	Bharatiya Nabhikiya Vidyut Nigam Limited
BIS	Bureau of Indian Standards
BoP	Balance of Plant
CB	Control Building
CCC	Construction Completion Certificate
CCW	Condenser Cooling Water
CE	Chief Engineer
CMD	Chairman cum Managing Director
C&MM	Contracts and Materials Management
D (C)	Director (construction)
DR	Design Report
DCN	Design Change Notice
DGB	Diesel Generator Building
D (T)	Director (Technical)
EB	Electrical Building
ECN	Engineering Change Notice
ECR	Engineering Change Request
EP	Embedded Parts
F&A	Finance & Accounts
FB	Fuel Building
FCN	Field Change Notice
FE	Field Engineering
FS	Flow Sheet
GA	General Assembly
IAEA	International Atomic Energy Agency

IGCAR	Indira Gandhi Centre for Atomic Research
ISI	In-Service Inspection
ISNT	Indian Society for Non-destructive Testing
MCC	Motor Control Center
MIS	Management Information System
NA	Not Applicable
NDE	Non Destructive Examination
NCR	Non-Conformance Report
NPCIL	Nuclear Power Corporation of India Ltd.
NSSS	Nuclear Steam Supply System
PD	Project Director
PE	Project Engineer
PFBR	Prototype Fast Breeder Reactor
PSI	Pre-Service Inspection
QA	Quality Assurance
QA (C)	Quality Assurance (Construction)
QA (P)	Quality Assurance (Procurement)
QAP	Quality Assurance Plan
QC	Quality Control
QMS	Quality Management System
QS	Quality Surveillance
REG	Reactor Engineering Group
RCB	Reactor Containment Building
RO	Responsible Organisation
SAS	Site Assembly Shop
SB	Service Building
SGB	Steam Generator Building
STD	System Transfer Document
TB	Turbine Building

### **1.3. MANAGEMENT FUNCTIONS**

#### **1.3.1. PROGRAMME RESPONSIBILITY**

BHAVINI being the RO, is responsible for preparation and implementation of the over all QA Programme. The responsibility for the QA Programme in the area of Design is with REG, IGCAR, DAE which is the Principal Design Organization.

The contractors have the responsibility of establishing and implementation of QA Programme for the works awarded to them in terms of the respective contract requirements. The QA Programme of contractors will be in line with the requirements of QA Programme of BHAVINI and these will be reviewed for adequacy and accepted by BHAVINI. However, BHAVINI retains the over all responsibility for these QA Programmes.

#### **1.3.2. POLICY STATEMENT**

The Quality Policy of BHAVINI forms part of this QA Manual.

#### **1.3.3. ORGANISATION**

BHAVINI is governed by Board of Directors. The Chairman and Managing Director (CMD) is responsible for all technical, financial and administrative matters. CMD is assisted by Technical, Project and Finance Directors directly reporting to Chairman and Managing Director.

Presently, BHAVINI is constructing a single project namely, PFBR and the organization at present has the responsibilities for Procurement, Manufacturing, Construction, Commissioning and Operation of PFBR. There are two Directorates namely, Construction Directorate and Technical Directorate. Technical Directorate is responsible for procurement of components and equipment in addition to Field Engineering, which includes coordination with IGCAR, the Principal Design Organisation. The project construction / commissioning activities come under the purview of Construction Directorate. Both these Directorates are responsible for QA functions in their respective areas. The Heads of QA report to their respective Directors. The two Directors with the

assistance of Heads of QA are responsible for evolving QA policies, goals and objectives for BHAVINI. These are in turn approved by CMD BHAVINI. The Heads of Procurement Group and QA in Technical Directorate independently report to Director (Technical). In the case of Construction Directorate the Heads of various construction groups and QA independently report to Director (Construction). The QA groups are administratively independent of the groups responsible for execution and they are empowered to stop the work, in case of violation of QA requirements.

The two Directors are of Senior Level and are also Directors of the BHAVINI Board. They are considered responsible enough to ensure effective implementation of QA Policies.

## ORGANISATION STRUCTURE, FUNCTIONS AND RESPONSIBILITIES

Present Corporate Organization Chart is presented in page- 34.

### Functions and Responsibilities of Directors

- a) Director(Construction) / Project Director  
Responsible for Project Construction and Commissioning stages. QA during Construction and Commissioning. Heads of different functional areas in Project Directorate report to him.
- b) Director (Technical)  
Responsible for matters and issues related to Field Engineering, Procurement, Manufacturing, QA during Procurement, Manufacturing and Assembly, and obtaining Regulatory clearances. Regulatory clearances of BHAVINI are processed in consultation with REG, IGCAR. Heads of different functional areas in Technical Directorate report to him.
- c) Director (Finance)  
Responsible for Corporate finance functions. Heads of different functional areas in Finance directorate report to him.

### Functions and responsibilities of various Directorates

#### **Technical Directorate**

Technical Directorate is responsible for following functions:

- Field Engineering assistance during construction and commissioning stages of each project.

- Procurement of materials / equipment.
- Management of identified package contracts for procurement of equipment.
- QA during Procurement, Manufacturing and Assembly activities, including QA Programmes of suppliers.
- Overall coordination with external Design Consultants.
- Training of personnel in Technical Directorate.
- Co-ordination of Design / Engineering related developmental activities.
- Co-ordination with other Directorates.
- Co-ordination with IGCAR for design activities.
- Interaction with Regulatory Authority for obtaining clearances.
- Interfacing with DAE and other Ministries.
- Review of commissioning procedures and commissioning test results.

### **Construction Directorate**

Construction activities of PFBR project are managed by Construction Directorate which is headed by Director (Construction) / Project Director.

The Construction Directorate is responsible for following functions:

- Complete management of all construction and installation and commissioning activities at the project site.
- QA during Construction and Commissioning, including QA Programmes of all contractors and vendors.
- Procurement of free issue materials, if any, which are not in the scope of Technical Directorate, to be given to site contractors.
- Management of identified package contracts from the stage of tender enquiries which are to be based on the design specifications issued by Technical Directorate.
- Interactions with local State Authorities on project matters.
- Inspection of procured items on receipt.
- Material management and control at Sites.

- Review and issue of Pre-service and In-service Inspection Programme Documents for PFBR jointly by Technical Directorate and Construction Directorate.
- Pre-service Inspection of all items as per requirements of ISI Programme Document and issue reports. To implement corrective actions on deficiencies in items revealed by PSI.
- Coordination with other Directorates.
- Qualification and training of manpower for various construction, installation and commissioning activities.
- Establishing & maintaining Documentation Centre.
- Unit level administration, F&A, C&MM and Industrial Safety.

### **Functions of Chief Engineers of Quality Assurance**

Chief Engineers of Quality Assurance are responsible for two major functions viz. Quality Assurance and Quality Surveillance.

Quality Assurance functions are listed below. Services of eminent / qualified organizations / individuals will be identified and enlisted for some of these functions listed below:

- Issue, revision and control of Corporate Quality Management System Document.
- Review of technical specifications.
- Review of Quality Assurance System Manuals to be issued by Directors within BHAVINI.
- Review and acceptance of Quality System Manuals of Vendors and Sub-vendors as applicable.
- Review of test / inspection reports and analysis of the test results.
- Review of NCRs.
- Provide assistance / guidance / advice to various groups in BHAVINI for implementation of BHAVINI Quality Management System in general and for specific contracts in particular.

- Monitoring and review of effectiveness of implementation of Quality Management System within BHAVINI and at Vendors and Sub-vendors places. Take corrective actions, wherever necessary.
- Audit in all quality related activities of BHAVINI, its Vendors and Sub-vendors.
- Review and issue of Pre-service and In-service Inspection Programme Documents for PFBR.
- Assistance and advice to groups in construction sites in performing Pre-service and In-service Inspection.
- Analysis of Pre-service and In-service Inspection results. Defect growth analysis and remnant life analysis.
- Promotion of quality awareness through training programmes etc.
- Promotion of quality related qualifications of BHAVINI personnel, sponsorship to various courses and associated examinations.
- Interactions with AERB on quality related issues.
- Interaction with CMM of NPCIL / other groups in BHAVINI on vendor performance evaluation including arranging / carrying out pre-contract award vendor evaluation (Technical Directorate).
- Procurement of QA services.
- Establishing and maintaining Documentation Centre (Construction Directorate).
- Review and implementation of the process of continual improvement.

Quality Surveillance functions are:

- Quality Surveillance of materials/equipment/items as per purchase order/contract and approved drawings /technical specifications.
- Witness/verification of various routine and special qualifications such as welders, NDE personnel, operators and machines in respect of manufacture, construction, commissioning, examination and testing related activities.

- Issue of periodic as well as final QS reports giving important recordable information to serve as inspection history for the equipment/material. Pre-despatch quality surveillance, packaging, loading/unloading witnessing.
- Verification of calibration status of various measuring/ testing/examining instruments/machines used for examination/inspection.
- Issue of Shipping Release.
- Procurement of QS services.

### **Directorate of Contracts and Materials Management (CMM)**

This Directorate, functioning under NPCIL, will provide their services to BHAVINI. This Directorate is responsible for all contracts and materials management of procured items from the stage of tender to the stage of its delivery. Technical and administrative direction is provided by Project Director / Director (Technical) as applicable. CMM group at site administratively report to PD.

The Directorate of Contracts and Materials Management is responsible for following functions:

- Formulation of Purchase Policy and implementation of Purchase Procedures.
- Purchasing materials/equipment as per the engineering and tender documents prepared by requisitioning/indenting Directorate.
- Vendor evaluation for registration with the technical assistance of Quality Assurance and other groups in Technical Directorate as required.
- Finalization and management of commercial aspects related to Purchase Contracts.
- Arranging safe handling and transportation of equipment/raw materials.
- Clearing through customs and docks for imported materials/equipment.

- Management of stores including receipt, safe storing and preservation of material/ equipment / item, Issue and inventory control, material accounting.

All PFBR construction activities are divided into several groups, viz., Civil, NSSS, Piping, BoP (Mechanical Non-safety), Electrical, Control & Instrumentation, Planning, Contracts and Materials Management, Procurement, Quality Assurance, Field Engineering, Industrial Safety and Commissioning. Each group is headed by a Chief Engineer / Additional Chief Engineer / Project Engineer.

QA related functions shall be delegated to the Heads of Construction QA group and Procurement QA group which are responsible for overall effectiveness of the QA programme including procurement, manufacture, site assembly, site construction and commissioning. All the group heads including QA and FE shall have the support of qualified and experienced personnel in performing assigned tasks in conformance with the specified requirements.

Two types of interfaces shall be controlled during construction stage, viz. internal and external.

The internal interface is:

- Between Technical directorate and Construction Directorate.
- Between different groups of various Directorates.

The external interfaces are:

- Between groups at BHAVINI and IGCAR, NPCIL, HWB and other DAE Units.
- Between groups at BHAVINI and Regulatory Authorities.
- Between groups at BHAVINI and contractors / vendors/ consultants.

Design inputs in the form of design notes, design specification, technical specification and drawings shall be provided by the Principal Design Organization, i.e. Reactor Engineering Group, Indira Gandhi Centre for Atomic Research. Field Engineers / Consultants' Engineers shall be posted at site to provide day-to-day assistance on design aspects.

## **Responsibilities of Individual Groups**

It shall be the responsibility of the individual construction groups to ensure that all activities are performed to achieve the specified quality. While the individual major contractors are required to implement their own QA programme prepared in line with this QA manual and applicable technical specifications of tenders, it shall be the basic responsibility of the concerned group heads to ensure that appropriate QA manuals, QA plans, work procedures, work instructions are prepared, duly approved and implemented. Whereas the responsibility for quality control and inspection activities including incoming inspection, storage rests with the individual contractors / sub-contractors and by extension with the individual construction group heads, over all responsibility of quality assurance functions rests with the respective heads of QA groups.

The specific responsibilities of individual construction groups are briefly described below.

### **Procurement / Manufacturing Group**

Procurement / Manufacturing group shall be responsible for:

- a) Qualification of sources / vendors, procurement and follow up of components/equipments for NSSS and BoP.
- b) Preparation of Technical Tender Documents for NSSS and BoP.
- c) Site Assembly Shop activities and follow up.

### **Site Planning Group.**

Site Planning Group shall be responsible for Project planning, Scheduling and Budgeting, Management Information System, Internal co-ordination and liaison with others for expediting progress will control drawing office, archives and library and issue master list of current documents as received from FE.

All construction activities are planned in a systematic and sequential manner by Site Planning Group, and Head of Site Planning Group is responsible to prepare a detailed Master Control Network covering all major activities. Time schedule for each activity shall be arrived at on the basis of inputs of details of works spelt out in the contracts, inputs provided by the various agencies connected with the project execution work, earlier experience and fitting in with the over all project schedule. The equipment deliveries are tied up with these schedules.

Based on the Level-I Network, detailed plans for Civil, Mechanical, Piping, NSSS, Electrical and Instrumentation construction activities shall be prepared by the respective construction groups and coordinated by Head of Site Planning Group.

These plans include the following:

- a) Flow chart and schedule identifying the system and sub systems to be installed / commissioned and their relative sequence in the construction programme including time schedule for various inspection and testing activities.
- b) Identification of cross references of installation procedures, instructions and drawings.
- c) Identification of activities requiring services of sub contractors.
- d) Identification and authorization of individuals responsible for various activities, sequence of works & inspection and testing activities.
- e) Resources in terms of performing personnel, inspection and testing personnel, handling and rigging equipment tools, inspection and test equipment / tools and other tools etc. required for the performance of the activities.

Co-ordination meeting of concerned personnel shall be held at pre-determined intervals to review progress of work, to plan further activities and to resolve any outstanding problems.

#### Civil Construction Group

The following are the responsibilities of Civil Construction Group:

- a) Qualification of sources and procurement of all construction materials through civil contractors such as cement, admixture, aggregates, rebars, paints, caulking compounds required for construction of civil structures.
- b) Procurement, fabrication and erection of structural steel and embedded parts through civil contractors.
- c) Construction of all civil structures in nuclear and power islands inclusive of inspection & testing.

#### Nuclear Steam Supply System (NSSS) Group

- a) NSSS group is responsible for site related fabrication, erection, inspection and testing of NSS systems and equipments viz. Reactor assembly components, reactor

control and protective devices, fuel handling and fuel transfer system equipments, radiation shielding and sealing equipments, air locks, spent fuel receiving, inspection and storage equipments, secondary sodium circuit components etc.

b) In addition, following auxiliary systems are also assigned to this group:

- \* Ventilation Systems for Reactor Containment Building, Control Building, Service Building Fuel Building and Turbine Building.
- \* Auxiliary systems like Argon and Nitrogen systems.

#### Piping Group

Piping group shall be responsible for fabrication, erection, inspection and testing of following piping systems and equipments:

- a) Entire Sodium Piping of NSSS
- b) Auxiliary Services Piping catering to NSSS
- c) Fuel Handling Process System
- d) Common Services

#### Balance of Plant – Mechanical (Non safety related) group

BoP-Mechanical group shall be responsible for site fabrication, erection, inspection and testing of following equipment and systems:

- a) Erection of equipments: Boiler feed pumps, condensate extraction pumps, feed water heaters, de-aerating feed water heater tanks, auxiliary feed pumps, main steam isolation valves and other special purpose valves.
- b) Piping for turbo generator.
- c) Condenser cooling water pump house package.
- d) Main steam condenser and on line tube cleaning system.
- e) Turbo generator.

#### Electrical Group

Electrical group shall be responsible for all works concerned with incoming material inspection, storage / preservation, execution and supervision of installation, erection and testing of all electrical power equipment, switchgears, M.C.C, emergency power supply, switch yard (power evacuation facilities), cabling, lighting and construction power supply. Scope covers both NSSS and BoP electrical works.

### Control & Instrumentation (C & I) Group

Control and Instrumentation group shall be responsible for incoming material inspection, storage / preservation, execution and supervision of all works concerned with assembly, erection, testing of all control room and main plant instrumentation covering NSSS and BoP, public address and communication systems.

### Contracts and Materials Management (C&MM) Group

C&MM, NPCIL, Mumbai is responsible for processing tenders for manufacture / procurement of all major components. Site C&MM Group is responsible for procurement of items not delegated to C&MM, NPCIL, receipt of all materials handed over to BHAVINI, their storage, safe custody and issue of materials to respective user groups, coding, accounting and up-to-date maintenance of relevant records, disposal of scrap, surplus and unserviceable items, indenting of general use material such as stationery, oil, grease, paint, cotton waste, cleaning material, general tools, electrical consumables and coordination with package contractor concerning storage and handling of items received at project site for installation and erection in various systems.

### Quality Assurance (QA) Groups

QA (Procurement) and QA (Construction) groups shall be responsible for QA functions in their respective areas. QA (Construction) group shall be responsible for ensuring effective implementation of approved site QA Programme by the Construction agencies. QA (Procurement) group is responsible for ensuring quality and workmanship in manufacture of components and equipment at manufacturers' shops by QS engineers stationed at the manufacturers' sites, by deputing QS engineers and/or by engaging third party inspection agency. QA (Procurement) group is also responsible for ensuring quality for works at site assembly shop. Heads of QA groups shall have the authority to initiate and implement any preventive and / or corrective actions that may be deemed necessary to ensure effectiveness of the QA programme implementation. Respective QA head is authorized to witness, undertake surveys, carry out additional checks / tests as required, audit all the activities and enforce corrective and preventive measures where practices detrimental to the quality are noticed. They are authorized also to stop or suspend work due to significant deviations noticed, which will affect the quality of work. It is being envisaged that the respective package contractors shall execute all Quality Assurance, Quality Surveillance and Inspection functions. QA functions in the form of

verification and audit activities shall be carried out by QA (C). QA groups shall execute the following functions in their respective areas:

- To ensure establishment and effective execution of established QA program at project works.
- To review and approve various inspection, and testing procedures in consultation with Field Engineering and erection groups.
- Ensuring appropriate qualification of all inspection, and NDE personnel.
- Ensuring qualification of all NDE, welding and brazing procedures.
- Ensuring qualification of all welders / welding operators and brazers / brazing.
- Ensuring qualification of Operators.
- Ensuring qualification of all painters / painters.
- Inspection and verification of consumables to be used in welding and NDE.
- Ensuring satisfactory implementation of various NDE methods including Visual Examination (VE), Radiographic Examination (RE), Magnetic Particle Examination (MPE), Liquid Penetrant Examination (LPE), Ultrasonic Examination (UE), Leak Testing (LT), and Eddy Current Examination (ECE) etc.
- Ensuring implementation of QA plans for fabrication, installation, erection, inspection and testing of various systems and components.
- Training and qualification of QA personnel in inspection, testing and QA methods as required.
- Auditing and certification of construction completion of various systems.
- Review of Contractors' / Sub-contractors' QA manuals.
- Review of QA Plans.
- Review of NCRs.
- Review of results of PSI.

The Concrete Testing Laboratory will be established by the main Civil contractors and certified by QA (Construction) group.

#### Field Engineering (FE) Group (Technical Directorate)

FE group shall assist the construction groups by providing design assistance and solutions to equipment/system physical interference problems in equipments/ systems, arising during construction. FE group shall also be responsible for review and

concurrence of erection and test procedures, certification of construction completion and system transfer documents, disposition of non-conformances and their control. It will liaise with REG, IGCAR and issue construction drawings and specifications in all disciplines, design change notes etc. It is responsible for document control of design drawings, specifications and other design inputs for site construction. FE shall maintain and make available periodically to Procurement and Construction groups a Master List of current documents as received from REG,IGCAR.

Design clarification as required by construction groups, shall be provided by Field Engineering group in the form of relevant briefs, intents of design and necessary engineering detailing.

#### Industrial and Fire Safety Group

Industrial and Fire Safety group shall be responsible for ensuring safety in all the activities, formulation of accident prevention programme, preparing safety procedures, procuring safety appliances, safety educational / motivational training, reporting all accidents and unusual occurrences, accident analysis, industrial health and occupational hazard control, co-ordination with the Fire Safety Organization and inculcate safety culture.

Following shall be the role of the Industrial and Fire Safety Group:

- Enforcement of safe working practices throughout the project.
- Monitoring of unsafe conditions and practices by regular site inspection, suggesting rectification and prevention measures and follow up action.
- Reporting accident cases with details to statutory and departmental authorities.
- Carrying out spot investigation immediately after the accident, and subsequently convening the Inquiry committee meetings and preparing detailed reports with suggestions for preventing recurrence of the same.
- Advising concerned engineers to maintain safe working condition at site as per different statutory acts and rules.
- Issuing monthly and annual statistical data and analysis for general information.

- Inculcating safety consciousness amongst the staff by way of periodic lectures.
- Arranging documentaries, display safety posters and safety incentive awards.
- Inspection, testing and procurement of safety appliances.
- To see that the rules and regulations laid down in the safety manual shall be observed.
- Coordination with Fire Safety Organization in MAPS and other units.

In such circumstances where safety engineer feels that any unsafe condition / practice is likely to result in serious accident involving human life, damage to equipment / building, he shall be authorized to stop the work, impound the faulty equipment and initiate imposing fines and penalty on the contractor action against safety lapses with intimation to the concerned group heads.

#### Commissioning Group

The responsibilities of the Commissioning Group include all commissioning activities as per the norms and procedures for commissioning of various equipment and systems.

#### 1.3.4. STAFFING, TRAINING AND CERTIFICATION

##### STAFFING:

Design, Construction, Commissioning and associated QA activities are carried out by competent personnel having necessary educational qualification and experience in the relevant areas.

##### TRAINING AND CERTIFICATION:

All personnel performing activities affecting quality are qualified on the basis of general education, experience and proficiency required for carrying out a specific assigned task.

The task of selection, training, qualification and certification of personnel employed shall be so accomplished that the required quality awareness and attitude shall be generated among all personnel, and the activities performed by them meets the specified quality.

Engineers and Scientists are largely from BARC Training School where training in Nuclear Engineering and Science and related fields is imparted in a year-long course. Others are given in-house orientation training and also given on the job training before they are given specific responsibilities. All engineers and scientists are periodically sent

to various courses to acquire state-of-the-art professional knowledge. All engineers and scientists are trained to acquire sufficient knowledge of the QA system applicable to Nuclear Power Plants.

Where required by codes, standards, specifications or other specific requirements, personnel performing activities affecting quality obtain necessary training / qualification / certification and / or, re-training / re-certification / re-qualification from BHAVINI. These include personnel of contractors.

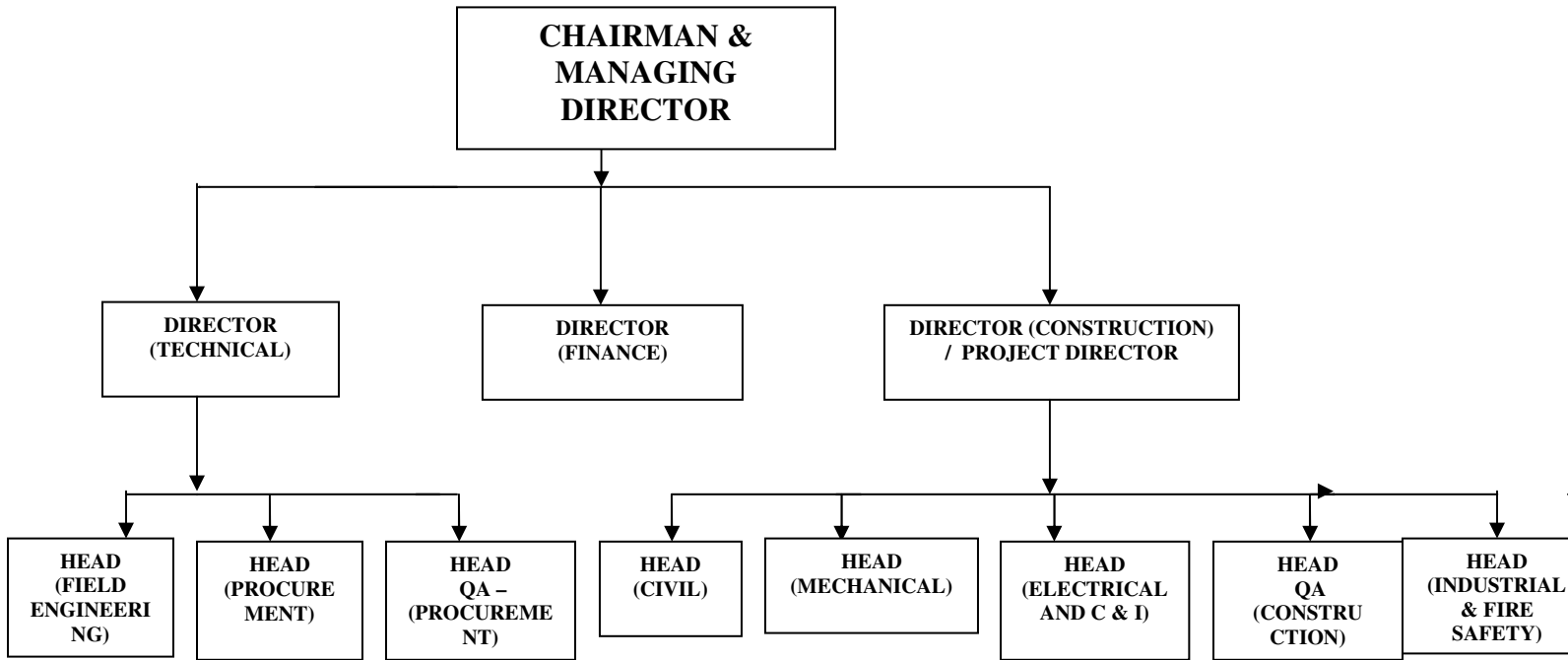
Duly qualified welders as per approved Welding Procedure Specifications and Procedure Qualification Records are permitted to carry out welding on the job. Inspection is carried out by qualified personnel. NDE professionals are trained and certified by the National Certification Body of Indian Society for Non-Destructive Testing (ISNT) or American Society for Non-Destructive Testing (ASNT). Before submission of NDE / inspection reports, the reports are duly signed by qualified NDE personnel and inspection engineers. Where NDE is specified, the same is carried out by competent and certified personnel as per the approved procedures.

In many special areas / tasks, as applicable, procedures are established for the qualification of personnel on the basis of workmanship and / or any other set criteria. Wherever special skills are needed for carrying out identified specialized work, such personnel are trained in-house appropriately or through training agency which provides such training. The qualification records of all the personnel are kept current.

Formal training programmes like BARC Training School, NDE Professional Training etc. are governed by Training Manuals and syllabi which are reviewed and updated continually taking into account the state-of-the-art in the technology.

There is provision for continuous monitoring of the performance of all task performers and for re-training and re-qualification / re-certification, in the event of their failure to perform satisfactorily.

Respective Groups are responsible for training and qualification of their personnel and for ensuring training and qualification of personnel of the contractors / consultants engaged by them.



**ORGANISATION CHART OF BHAVINI**

### 1.3.5. QA PROGRAMME

This QA Manual prescribes the QA Programme which is consistent with AERB requirements as per Code of Practice on Quality Assurance for Safety in Nuclear Power Plants AERB Code No. SC/QA June 30, 1988.

#### Graded Approach

In implementing this QA Manual, a graded approach will be adopted in respect of each item, services or process. The extent of enforcing the QA requirements / efforts will be based on the effect of non compliance that can have on safety. In addition the graded approach will also take in to account issues such as:

- Complexity or uniqueness of the item;
- Degree of standardization of the item;
- Need for special controls, administrative measures and surveillance over processes, methods and equipment;
- Degree to which compliance with design requirements can be demonstrated by inspection and test;
- Quality history;
- Accessibility of the item, after installation in the plant, for maintenance, in-service inspection and replacement; and
- Economic implications of failure.

#### Quality Assurance Programme of Contractors

Individual package contractors shall prepare their own construction quality assurance manuals in line with this QA manual. The contractors' QA manuals shall detail the quality assurance program of contractors to effectively carry out quality control and inspection functions of their works at the project and shall be supplemented by specific QA plans and NDE work procedures. All these QA documents shall be duly reviewed by the respective QA groups, concurred by Field Engineering and approved by the designated personnel of BHAVINI.

The Quality Assurance Manuals prepared by the contractors shall generally contain but not be limited to the following:

- a) Description of the items, processes and services as applicable.
- b) A statement relating to management's commitment to quality.

- c) Organization chart for the activities clearly showing the organizational structure, functional responsibility, line and levels of authority. It shall be ensured that personnel performing QA activities shall not have direct responsibilities for physical progress of the work.
- d) Identification of major activities, viz., design, material procurement, fabrication, erection, inspection and testing, pre-commissioning etc.; a list of QA plans and work procedures to be prepared and approved for each of the activities.
- e) Identification and control of special conditions such as environmental conditions, equipment and skills required for accomplishing activities affecting quality.
- f) QA programme and schedule for QA programme review.
- g) Procedure for non-conformance control.
- h) Training and certification requirements of personnel of Contractors / Sub Contractors performing and / or verifying the activities.
- i) Audit (Internal and External).

Contractors shall ensure establishment of similar effective Quality Assurance Programme of their Subcontractors. These will be reviewed by BHAVINI.

#### Revision Control of QA Manual

Revision, addition or amendment of the QA Manual shall be identified, recorded and distributed as follows:

The pages which shall be altered or revised shall be marked with revision number at the top of the page. The pages shall be signed with date by the approving authority as "REVISION" or "ADDITION". To facilitate locating alterations on the pages, the words / sentences altered shall be identified by underlining.

Such revised sheets shall be issued immediately after approval with a covering sheet called "Revision Control Sheet" listing the revised pages to be exchanged with old pages along with the details of the revised text.

In case of major revisions affecting many pages, or after many revisions of individual pages, the entire document shall be revised and issued as next issue.

Approved copies of QA Manual and its subsequent revisions / issues shall be recorded and distributed to the authorized functionaries.

### 1.3.6. QA PROGRAMME REVIEWS

This Quality Assurance Manual shall be reviewed periodically at least once in three years and revised as necessary to reflect programmatic and organizational changes. In case of no revision, "No Change" position shall be recorded and issued. Revisions to this manual shall be approved in the same method and stages as the approval of the original issue.

## **1.4. PERFORMANCE FUNCTIONS**

### **1.4.1. DOCUMENT CONTROL**

#### Drawings and Specifications

All the construction activities shall be carried out following approved documents. The drawings and specifications for all the main plant items shall be prepared, checked and approved by Reactor Engineering Group of IGCAR or their authorized consultants and shall be made available to the Field Engineering group at project site for construction. Field Engineering shall maintain and make available periodically a Master List of current documents for procurement and construction as received from REG/IGCAR.

Requests / proposals for Design modifications including those from contractors will be put up to Field Engineering. These will be processed as Design Change Requests / Field Change Requests. FE / Consultant shall issue DCN and FE group shall issue FCN. These documents shall be forwarded to construction group for implementation. Such documents shall be incorporated in subsequent revision of the drawing. After the design / drawings are frozen, whenever necessary, FE group shall issue ECN which shall be forwarded to construction group for implementation.

Field engineering group ensures that the latest drawings FCN/ DCN/ ECN, specification, etc., issued by Consultants are received at site well in advance for execution of work. The list of drawings, FCN/ DCN/ ECN, specification, etc. shall be circulated to all the construction agencies. Construction groups shall obtain latest drawings/specifications from FE group to carry out the construction work. All construction groups shall control the documents / drawings to ensure the following:

- (a) The latest authorized documents shall be used in the work areas.
- (b) Obsolete documents shall be promptly and positively removed to preclude their inadvertent use.
- (c) Timely information of revision of documents and issue, and the actual status shall be promptly relayed to all the authorized functionaries and organizations / agencies.
- (d) Wherever applicable, detailed drawings based on FS / GA shall be made by the contractor and approved by FE.

## Management Procedures

A set of management procedures, shall be prepared and approved in addition to the specific procedures to be prepared by the individual contractors. This includes but not limited to the following:

- Procedure for Preparation of Procedure
- Drawing office procedure
- Vendor Evaluation Procedure
- Procedure for Management Review of QA Programme
- Material receipt, inspection, storage and issue
- Audits
- Control of Non-Conformance
- Work Procedures
- Record and Documentation
- Hand over / Transfer of systems, construction documents

Detailed procedures shall be prepared, based on the applicable specification and drawings, by individual construction groups / contractors.

The procedures generally contain the following:

- Title, description of activities, identification number, revision number, date and approval status.
- Scope of work.
- References such as codes, specification, drawings.
- Pre-requisites.
- Pre-qualification of the personnel performing the work, equipment and process.
- Precautions to be taken for the safety of personnel and equipment during installation, inspection and testing.
- Detailed instruction, checklist or QA plan for the installation and other activities including identification of witness hold points and records required.
- Acceptance standards.

In case of complex and critical works such as installation of NSSS components, details of sequential operations shall be listed and followed by route cards. The route cards shall incorporate all the check points to document the entire operation.

All the procedures of Civil / Mechanical / Reactor Assembly / Piping / Electrical / Instrumentation works shall be approved by the respective Heads of groups.

QA Plans, NDE and PSI procedures shall be reviewed / approved by the respective Heads of QA groups.

Procedures, QA Plans and instructions / schemes are reviewed by FE group before approval.

#### 1.4.2. DESIGN CONTROL

The responsibility for Design is with REG, IGCAR. REG, IGCAR have a QA Programme in Design which is reviewed by AERB. REG, IGCAR may assign Design Works to consultants who in turn have a QA Programme acceptable to REG, IGCAR and BHAVINI.

Field Engineering Group of BHAVINI interfaces with REG, IGCAR with regard to Design. Design Inputs received from REG, IGCAR are issued by FE through various groups in BHAVINI for implementation.

Requests / proposals for Design modifications including those from contractors will be put up to Field Engineering. These will be processed as Design Change Requests / Field Change Requests. FE / Consultant shall issue DCN and FE group shall issue FCN. These documents shall be forwarded to construction group for implementation. Such documents shall be incorporated in subsequent revision of the drawing. After the design / drawings are frozen, whenever necessary, FE group shall issue ECN which shall be forwarded to construction group for implementation.

The Revision in Design Documents is processed by FE on the same lines as the original design document. It is the responsibility of the user group to ensure that latest revisions of Design Documents are used in their respective areas.

#### 1.4.3. PROCUREMENT CONTROL

##### Procurement Control and Vendor Qualification

Procurement of material / equipment for BHAVINI shall be undertaken as follows:

Indenting, Tendering, Manufacturer / Vendor evaluation, Manufacturing, Inspection, Testing and Supply.

All the activities related to the procurement of major equipment shall be coordinated by Procurement / Manufacturing Group of Technical Directorate. However, processing of tenders for major equipments will be the responsibility of C&MM group, NPCIL.

## Procurement Activities

Following activities are performed in procurement of components / equipment / services (referred to as "Product")

- a) Preparation, review, approval, distribution and change control of
  - Technical specification
  - Tender document
- b) Vendor/shop evaluation and qualification, scrutiny of manufacturer's QA Manual, as necessary.
- c) Technical evaluation, identification of technical deviations from the Tender document and their acceptance/rejection.

Activities (a) to (c) are completed before issue of tenders / placement of purchase order. After placement of purchase orders following activities are completed.

- d) Approval of various manufacturing and QA documents like QA plans, manufacturing procedures, manufacturing sequence, manufacturing drawings, qualification of procedures, NDE and testing procedures, packing procedures etc.
- e) Quality Control and Surveillance (including specific "Hold", Witness and Review stages)
- f) Compilation of Manufacturing Records / Documents of as built product (Component/equipment)
- g) Evaluation of performance of the product (Component / equipment) within post warranty period.
- h) Control of non-conformances and follow-up on corrective actions
- i) Generation and control of QA records for inspection, NDE and other tests.
- j) Issue of shipping release

The activities (d) to (g) above are basically part of manufacturing but are mentioned here under procurement since the procurement documents must specify these requirements, specifically in case of procurement of raw materials, consumables etc.

For standard items and bought-out items, the acceptance is based on final inspection and type tests as per specifications.

The contractor/ manufacturer / vendor / sub-vendor prepare and submit their QA manuals in line with this QA Manual of BHAVINI.

#### Procurement Procedures

After identifying the need for procurement of the product for the Project, tender specification will be prepared by Technical Directorate, BHAVINI for the product clearly identifying technical requirements. The technical specification prepared by REG as part of design activity is used for procurement purposes. The technical specification includes scope of work, technical requirements (manufacturing, chemical, mechanical, electrical etc.), inspection and testing to be done on the product and their acceptance requirements, QA requirements, documentation requirements, packing, handling, transportation, shipping and storage requirements.

A tender document is then compiled. The tender document is final compilation of procurement requirements of the product indented, which is used for floating the tender enquiry to the prospective bidders. After the tender document is compiled, indent is raised. The indent is approved by competent authority. The approved indent is sent to CMM / NPCIL along with Tender Document for further tendering actions.

The capability and quality system of vendor/ sub-vendor is assessed by QA group along with Procurement and Field Engineering groups in Technical Directorate, BHAVINI. On the basis of safety category, reliability, performance requirement, manufacturing intricacies and pre-qualification, the indenter may identify the mode of purchase and recommend possible sources of supply and suggest appropriate procurement actions.

On receipt of bids, the indenter prepares technical evaluation and identifies technically acceptable and manufacturing-wise capable bidder(s). Deviations from the specified requirements are listed by the indenter and reviewed with the Field Engineering group of Technical Directorate / designated engineer / committee before the award of contract. Bids are evaluated taking various factors into account to ensure that quality and schedule are met by the prospective bidders. For regular suppliers of identical items, whose quality systems and capabilities have already been established and put under approved vendor list for particular items, specific vendor evaluation may not be done for repetitive requirements / procurements.

After selecting technically acceptable and capable procurement source, the purchase recommendation is then processed for approval from competent authority. The approved purchase recommendation along with technical portion, as necessary, to be included in the purchase order, is sent to CMM / NPCIL for placement of purchase order. A copy of P.O. with technical specifications is forwarded to Director (Technical) for arranging QS activities.

After award of contract, the supplier submits the manufacturing procedures, NDE procedures, inspection and testing procedures and QA Plans conforming to the specifications. Manufacturing documents are approved by Procurement Group of Technical Directorate. Inspection and testing procedures, QA Plans and QA documents are approved by QA (Procurement) group. Approved documents are sent to the supplier by the Technical Directorate, BHAVINI. Quality Surveillance is carried out as per the approved QA plan, approved manufacturing procedures, approved inspection & testing procedures.

Responsibilities for Preparation, Review and Approval of Tender Documents in Technical Directorate, BHAVINI.

a) Indent

Indent is raised by indenter and approved by competent authority.

b) Technical Specification

Technical specification includes technical requirements, scope of work and supply, applicable drawings, specifications, standards and documents, QA requirements, inspection and testing, surface treatment, storage, handling, packing, transportation and delivery conditions. Technical specification is prepared and approved by Reactor Engineering Group, IGCAR.

c) Tender Document

Tender document is compiled by indenter and checked and approved by Head, Procurement Group in Technical Directorate of BHAVINI.

d) Tender Evaluation and Purchase Recommendation

Bids are evaluated and purchase recommendation is prepared by indenter and approved by competent authority.

e) Request for Quality Surveillance is sent by Head, Procurement Group to Head, QA - Procurement group.

- f) QS Agency is decided by Director (Technical), BHAVINI.
- g) Changes, if any, to the procurement documents undergo same levels of review and approval as followed for the original document.

#### Procurement of Standard Bought Out Items / Proprietary Item

The design engineer gives due consideration to availability of standard products/ mass produced items and makes use of such products to the extent possible. Similarly, proprietary items from proven and reputed suppliers are considered and specified on the basis of catalogue data and manufacturing quality standard.

#### Procurement of Commercial Grade Products

Commercial grade / off the shelf products with proven quality may be requisitioned by the designer with additional tests / examinations to confirm its quality and accepted for use provided it meets the quality requirements for the intended use. The additional tests / examinations are done in-house or through an approved lab after procurement of the item but before it is put to use.

#### Procurement of Spares

Spares are procured as per the technical specifications and QA requirements for the original product. Additional requirements for long storage are duly specified.

#### Quality Compliance and Verification

The inspection, testing and verification activities are carried out as per the approved QA plans based on the technical specifications of the purchase order.

#### Control of Personnel

Duly qualified welders as per approved WPS and PQR are only permitted to carry out welding on the job. Inspection is carried out by manufacturer's qualified personnel. Before submission of NDE / inspection reports, the reports are duly signed by qualified NDE personnel and inspection engineers. Where NDE is specified, the same is carried out by competent and certified personnel as per the approved procedures.

## Disposition of Non-Conformances

The supplier establishes procedure to control materials, parts, components, systems or processes that do not conform to the specified requirements. The procedures provide for prompt recording and reporting of non-conforming products to Technical / Construction Directorate. The non-conforming products are promptly segregated (physical separation and tagging) to prevent their inadvertent use subsequently. The non-conformances which the supplier proposes for consideration and disposition in the form of Non-Conformance Report (NCR) are reviewed by Engineers of Procurement group and QA (Procurement) group and forwarded along with their comments to the Field Engineering Group for suitable disposition in consultation with REG, IGCAR. The NCR is "Approved" or "Approved as Noted" (i.e. approval with specific noting) or "Rejected" by Head of Field Engineering Group.

The following details are to be included in the NCR by the supplier:

- Description of non-conformance and its co-relation with relevant drawings / specifications / requirement / purchase order.
- Reasons for occurrence of non-conformity.
- Supplier's disposition proposal along with necessary detailed analysis and justification. Corrective actions to avoid recurrence.

Any significant design concession on items important to safety is brought to the notice of AERB.

## Shipping Release

The items are dispatched by the supplier only after obtaining written shipping release document from identified and authorized persons.

## Material / Equipment Procurement covered under the scope of Package Contractors.

For all the equipment / material covered under the scope of the package contractors, tendering, vendor evaluation, manufacture, supply, inspection and testing shall be the responsibility of package contractors. Purchase order shall be placed by the package contractors only on those manufacturers / vendors for which approval of Technical Directorate has been obtained. Inspection and checks during / after procurement / manufacturing and supply of such items shall conform to approve QA plans.

Capabilities of the supplier / sub-contractor shall be evaluated first by the package contractor and approved by Technical Directorate. This evaluation includes first hand assessment of their resources in terms of trained / qualified manpower, equipment / facilities, their quality control system and practices, scrutiny and concurrence of contractor / supplier's QA manual and their past performance on similar works carried out for nuclear power plants and other such reputed organizations.

#### 1.4.4. CONTROL OF ITEMS

##### Receiving and Inspection

All materials / equipment procured shall be delivered at site on due inspection and clearance by respective QA group or its authorized representative. As soon as the materials / items / equipment are received at site, they shall be visually inspected by concerned site construction group, prior to acceptance at site. All materials / equipment procured by package contractors shall be inspected and released for site as per approved QA Plan. On receipt at contractor's premises at site, an audit of all the procurement and manufacturing QA performed by QA (Procurement) personnel shall be carried out by QA (Construction) to ensure that the items meet the specification requirements. Further, visual inspection shall be carried out by contractor's QA personnel and concerned site construction group for any transit damage and correlation with despatch documents. Involvement of QA (Construction) shall be called for whenever transit damage is observed and dispute arises due to ambiguity in the documents and material quality. For accepted material "Material Acceptance Report" shall be prepared. In case of any deficiency in the received material, appropriate report shall be generated by the concerned site construction group and marked to respective QA group.

Inspection / verification reports shall be prepared and issued with clearly defined storage instructions. In case, certain test/checks not carried out on items in the shop and to be carried out at site as noted in shipping release, the same shall be carried out at site by the concerned site construction group and witnessed / accepted by QA (Construction) as per specification / drawing prior to acceptance at site.

##### Storage and Preservation

The storage of all the material and equipment shall be undertaken at the site stores and / or in the specified area prior to their installation and use. Storage of material / equipment shall be undertaken to ensure due identification, segregation and location and to prevent deterioration of quality due to such effects as corrosion, contamination, climatic conditions and physical damage. In general, the following aspects shall be taken into consideration for storage:

- a) Access to storage area.
- b) Cleanliness and house keeping practices.
- c) Secured and safe storage
- d) Fire protection.
- e) Identification and marking.
- f) Record of locations.
- g) Protective covers and seals.
- h) Coating and preservation.
- i) Special environmental conditions like temperature and humidity control, inert gas blanketing, etc.
- j) Preservation maintenance especially in the case of machinery.

Periodic inspection shall be carried out to ensure that specified preservation and storage conditions are maintained. The expiry date of consumables shall be clearly displayed so that the items such as paints shall not be issued for use after expiry of shelf life.

In general all nuclear components, instrumentation / control / electrical / electronic items, rotating machines, valves and pipe fittings and stainless steel items shall be stored under covered storage. The equipment or materials of high precision requirements such as stainless steel valves and pipe fittings for nuclear systems shall be segregated and stored at separately identified locations in the stores, to prevent any possible mix-up with other similar items. Due documentation of the storage records shall be maintained.

For long term storage of critical equipment, preservation procedures shall be prepared and approved. Storage of such equipment and their periodic inspection and maintenance shall be carried out according to these procedures.

The above storage and preservation procedures are applicable to the items procured by the contractors also.

## Protective Coatings Control

Protective coating shall be applied wherever specified to the items and surfaces to preserve their quality. Painting shall be undertaken in accordance with approved procedures. The type and extent of protective coatings shall conform to the requirements specified in the design drawings / specifications. The procedures shall include the following considerations:

- a) Use of only tested and approved material ensuring that the chemical elements in the coatings are maintained within specified limits so as not to have any deleterious effect on the surface.
- b) Expiry date of coating material.
- c) Adequate surface preparation / cleaning to be undertaken prior to application of paints.
- d) It shall be ensured that painting / coating does not interfere with testing / non-destructive examination of components. Wherever there is a possibility of protective coating interfering with any subsequent testing or NDE, the ease of resolvability of coatings during such testing shall be taken into account at the time of coating.
- e) All repair of damages to painted surfaces shall be undertaken following approved procedures.
- f) Suitable precaution shall be taken to avoid damage to nearby equipment during painting / coating of the specified equipment.

## Handling

Transportation and handling of all the critical components at Site shall be undertaken as per approved procedures. These procedures shall take into account weight, size, physical configuration, surface finish, susceptibility to shock damage and prescribed handling points. In case of complicated and critical structures, special handling devices and equipment shall be used. All lifting tackles and handling equipment to be used shall be tested and qualified before use on the job. They shall be also maintained and checked periodically as per applicable standards / procedures. Operators handling critical equipment shall be qualified for their use by special training or by experience.

## Identification Control of Material / Equipment

All the material and equipment including partly fabricated assemblies shall be identified with proper number / marking. It shall be ensured that the identification is maintained either on the item or on records traceable to items, throughout storage, fabrication, testing and installation. These measures shall be designed to prevent the use of incorrect or defective items and items which have not received the required examination, test or inspections. The identification marks shall be applied using methods and materials which shall be legible and not detrimental to the item involved. The identifications shall be marked on areas so as not to interfere with the functional or quality aspect of the item.

### 1.4.5. & 1.4.6. PROCESS CONTROL (MANUFACTURING, SITE CONSTRUCTION & COMMISSIONING)

All activities affecting quality in the areas of manufacturing, Site construction, commissioning and associated QA / QC are controlled in accordance with specified requirements to meet the design intent.

Wherever required by codes / standards / specifications the activities are accomplished by deploying qualified / certified / authorized personnel. All activities are carried out using approved, latest documents.

QA Plans with Control Points – review, witness and hold points are prepared for all activities affecting quality.

### HOUSE KEEPING

House Keeping and cleanliness are ensured throughout the plant with a view to maintain quality of items during storage / fabrication / site construction / installation / commissioning. Control of environmental conditions and access to various areas is ensured. Nuclear clean areas / clean zones / dust free areas are clearly identified and access to such areas is regulated.

Necessary house keeping and cleanliness procedures are issued giving details of the steps to be taken and the agencies responsible for various steps.

## **1.5. VERIFICATION FUNCTIONS**

### 1.5.1. VERIFICATION PROGRAMME

All activities affecting quality are verified for compliance with the specified requirements. It is ensured that Personnel involved in task verification shall not have any direct responsibility for task performance. Internal and External verifications are carried out.

### 1.5.2. INTERNAL VERIFICATION

Internal Verification is done for activities carried out by BHAVINI personnel.

### 1.5.3. EXTERNAL VERIFICATION

External verification is done of all Contractors' activities. The extent of such verification shall be based on the importance of the item or service, related to safety.

### 1.5.4. VERIFICATION PLANS AND PROCEDURES

All verification activities are performed as per approved verification plans in the form of Quality Assurance Plans. These Quality Assurance Plans shall:

- Identify reference documents including work procedures.
- Identify each verification point and indicate its relative sequence in the work cycle / process stages.
- Identify the characteristics to be verified at each point and link it to individual procedure.
- Indicate interfaces with other verification plans and specify how they shall be controlled.
- Identify control points, as Review Points, Witness Points and Hold Points.
- Identify how, when, where and by whom the verification shall be conducted.
- Indicate acceptance criteria.
- Indicate issue of reports.

#### 1.5.5. CALIBRATION AND CONTROL OF MEASURING AND TEST EQUIPMENT

Procedures shall be prepared prescribing the selection, identification, use, calibration requirements and calibration frequency of all measuring and test equipment / tools. The procedures shall be prepared based on applicability, recommended standards, recommendation of manufacturers of measuring and test equipment and experience of users.

It shall be ensured that all the measuring and test equipment for use shall be of proper range, type, accuracy and precision. Only calibrated and certified instruments shall be used. All the measuring and test equipment shall be numbered and a list describing the same shall be available with the user, indicating the due date of re-calibration.

The record of calibration shall be maintained on the measuring and test equipment, preferably in the form of adhesive labels or on records traceable to the equipment. The labels shall have at least following details :-

- (a) Date of calibration.
- (b) Date of validity of calibration.
- (c) Signature and name of authorized person performing the calibration work.
- (d) Signature and name of authorized person verifying the calibration work.

The measuring and test equipment found out-of-calibration or found damaged shall be deposited back in the section stores, with its condition written on an attached tag. Items already accepted by using these out-of-calibration equipment shall be assessed for their acceptability and suitable information shall be communicated to the affected groups / contractors. After repair, these measuring & test equipment shall be checked for calibration, and if found satisfactory, they shall be made available for use. A record of re-calibration shall be made as defined above. Rejected measuring and test equipment shall be stored separately in the section stores with its condition written on an attached tag. The rejected tools / equipment which shall be beyond repair shall be deposited at the Central Stores for final disposal.

Only qualified, knowledgeable and experienced personnel shall be authorized in writing, to perform calibration of measuring and test equipment and sign the record of calibration.

During any testing / calibration check, when deviations beyond prescribed limits are detected, an evaluation shall be made of the validity of previous measurements and tests, and acceptance of tested items shall be reassessed.

#### 1.5.6. VERIFICATION STATUS

The current status is indicated by the use of markings, stamps, tags, labels, routing cards, inspection records, physical location and other suitable means, which can indicate acceptability or non-conformance of items with regard to verifications performed.

#### 1.5.7. PRE SERVICE INSPECTION (PSI)

PSI of components and systems is carried out using approved procedures at stages identified by PSI document issued by REG, IGCAR. The calibration blocks used during PSI are identified for their traceability and preserved for future use during In Service Inspection (ISI) during the operation phase.

#### 1.5.8. AUDIT AND ASSESSMENT

##### AUDIT

A Comprehensive system of Internal & External Quality Audit is established in order to assess the effectiveness of the QA Programme as mentioned in this QA Manual.

Appropriately trained personnel, who are not directly responsible for areas being audited, shall perform and document the audits. They shall have sufficient authority and organizational freedom to make the audit meaningful and effective. Audit personnel shall be selected on the basis of:

- Knowledge and experience of auditing techniques;
- Knowledge of applicable codes, procedures and industrial processes.
- Specialized knowledge and experience in the area to be audited;

An Audit Team with a Team Leader is constituted jointly by Director (T) and Director (C) / PD.

An Audit Plan giving details of scope of audit, audit team members, and activities to be audited, Department / Organizations to be notified, applicable documents such as procedures and check lists and an annual schedule is issued at the beginning of every calendar year.

Internal Audits are performed in such a manner that all the Departments of BHAVINI are covered at least once in a year.

External audits are performed in such a manner that all the Contractors of BHAVINI are covered at least once in a year.

In addition, audits are carried out under the following conditions;

- When it is necessary to verify implementation of required corrective action;
- When significant changes are made in the functional areas of QA programme, such as significant re-organization or significant revisions of the procedure;
- When it is suspected that the quality of the item or services is in jeopardy owing to a deficiency, either in the requirements or the implementation of QA programme, and
- To ensure compliance with the observations of Regulatory Inspection.

The deficiencies identified and brought out by audit team would be addressed to:

- Determine the cause(s).
- Institute corrective actions.
- Rectify deficiencies.
- Review QA implementation policies required to eliminate recurrence of deficiencies.
- Impart training to personnel as necessary.
- Document audit reports and corrective actions taken.

The Audit Reports will be distributed to Functional Directors of BHAVINI, Heads of Groups in BHAVINI, Resident Heads of Contractors at site (only on audits pertaining to the specific contractor), for ensuring implementation of recommendations in a timely manner.

Implementation of corrective measures / recommendation will be ensured during subsequent audits.

The responsibility for compliance and implementation of the recommendation is with respective Directors.

## ASSESSMENT

Self assessment and independent assessment are planned in order to provide confidence and to take timely corrective actions. Areas such as interface management, safety, house keeping, training and qualification of personnel, preservation of installed equipment and records facility are assessed for their adequacy and improvements if any.

Assessment is carried out at least once a year by Top Management Team constituted by CMD. The results of assessment are communicated to CMD, Directors & Group Heads.

## **1.6. CORRECTIVE FUNCTIONS**

### **1.6.1. NON- CONFORMANCE CONTROL**

a) The equipment / material / items not conforming to the specified requirements shall be controlled as per approved non-conformance control procedure to prevent their inadvertent use. All agencies involved in procurement, manufacture, fabrication, inspection / testing and erection / installation activities shall be required to have their own non-conformance control procedures concurred by FE and respective QA.

b) All non-conformances observed shall be recorded in the inspection report and the non-conforming material / items shall be identified and kept aside until the non conformance are resolved. The reasons for non-conformances shall be identified and corrective action shall be taken to avoid their recurrence. Flow chart for disposition of non-conformance is given in page- 58. The format of Non Conformance Report is given in page- 59 &60.

c) All non-conformances shall be reviewed and deviations shall be processed. For disposition of non-conformances, recommendation on the NCRs shall be proposed by construction agencies, the same shall be concurred by QA and final approval / approval as noted / rejection shall be done by Field Engineer. 'Approved as noted' NCRs shall suitably be closed and registered. The various disposition methods shall be one of the following:

- Accept without modification – This decision shall be given when it is established that the proposed deviation shall not result in any impairment of quality and shall not have any adverse effect on its functional requirements.
- Re-work – The process by which a non-conformance item is made to conform to a prior specified requirement by re-machining, re-assembling or other corrective means.
- Repair – The process of restoring a non-conforming item to a condition such
- Reject – Not to be used for its intended purpose.

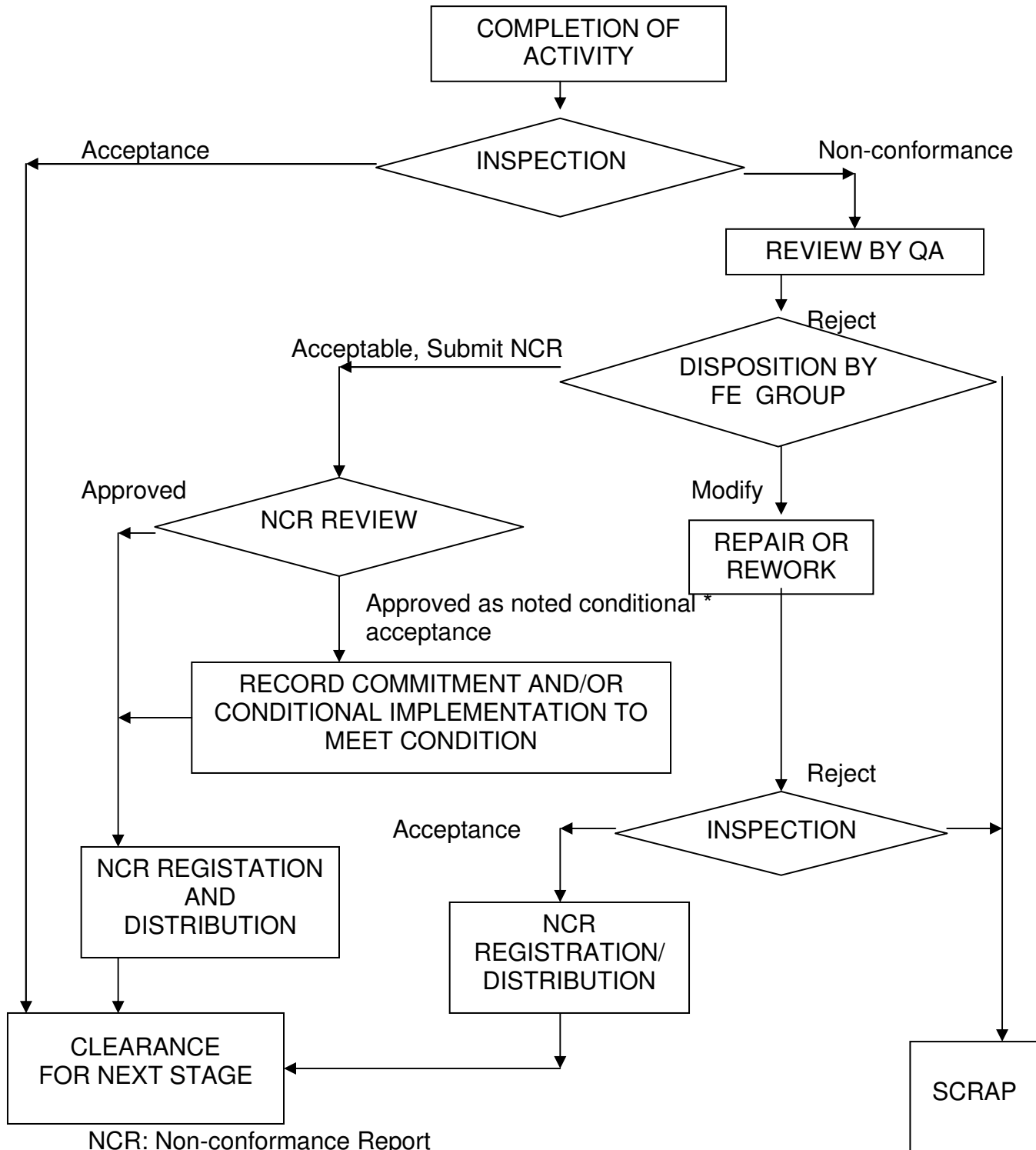
The control of NCR shall be done as per written procedure. The repaired and re-worked items shall be re-examined in accordance with the original specified requirements. A flow chart for disposition of non-conformance is enclosed.

Any significant design concession on items important to Safety will be brought to the notice of AERB.

#### 1.6.2. CORRECTIVE ACTION

The Non Conformance Reports are periodically analyzed for their causes and necessary corrective actions are initiated to remove the deficiencies so as to prevent repetition.

## FLOW CHART FOR DISPOSITION OF NON-CONFORMANCE



NCR: Non-conformance Report

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

BHARATIYA NABHIKIYA VIDYUT NIGAM LIMITED  
(A Government of India Enterprise)  
PFBR Project, Kalpakkam

NON-CONFORMANCE REPORT

Application for disposition of non-conformances

P.O. No.(See Note-1 on back side) .....

NCR No. ....

Project/USI No. ....

Contractor / Sub- Contractor .....Component/System/Structure/Item  
.....

Manf / Contractor's Ref. No. .... Spec.No./Drg. No. ....

Equipment / Tag No..... P.O. Item No. ....

-----  
Details of Proposed Concession: (See Note-2 on back side)

This request does not involve a change in contract price.....

Estimated cost .....

(Name, Designation, Date and seal ) Requested by.....

-----  
Quality Surveyor's comments (See Note-3 on back side)

Name..... Original signed ..... Date.....

APPROVAL OF INDENTOR / DESIGNER / CONSULTANT / FE (See Note-4 on back side)

APPROVED

APPROVED AS NOTED

REJECTED / REPAIR / RE-WORK.

NOTES:

(Name, Designation & Date) Indentor / Designer / Consultant / FE

Immediate Superior/ACE / CE/ Head, FE

CLOSING DCR IN CASE 'APPROVED AS NOTED' VERIFICATION BY QUALITY SURVEYOR OF  
MANUFACTURER/ CONTRACTOR / SUB-CONTRACTOR/ QA, IGCAR or its nominee

All stipulations in conditional approval met? Yes / No

If No, defective item repaired / rejected? ..... If repaired, new NCR No.....

(Name, Designation & Date) Contractor/Sub-Contractor QA, BHAVINI

Distribution:

CONSTRUCTION

Indenting group..... Head of Concerned Construction group .....

REG/IGCAR..... Head (QA).....

Consultant..... Head (FE) .....

Quality Surveyor..... Head, Site Planning Group.....

Contractor ..... History Docket .....

## NON-CONFORMANCE REPORT

(BACK SIDE OF NCR)

Note-1: For Package contract, please indicate Package P.O.No. and Main P.O./Sub.P.O. as applicable.

Note-2: This should include reasons for deviations and corrective actions to prevent repetition – enclose sketch, attach additional sheet, if necessary. If deviation is on quantified parameters, report the obtained parameters as follows.

Sl.No.	Design Value	Obtained Value	Remarks/Reason for deviation

Note-3: The purchaser's quality surveyor/authorized representative shall verify the deviations and ensure that the contractor has included all the deviations.

Note-4: In case of Field Engineering group, review process by immediate superior is optional.

## **1.7. QA RECORDS**

### 1.7.1. TYPES OF RECORDS

Records shall be prepared and maintained to provide objective evidence substantiating all the construction activities being carried out meeting the specified requirements of applicable codes, specifications and procedures.

They shall include, as applicable, the following:

- (a) Results of reviews, inspections, tests and audits.
- (b) Training, qualifications and certification of personnel.
- (c) Non Conformance Reports, repairs carried out.
- (d) Monitoring the performance of construction activities.
- (e) Qualification of procedures and equipment.
- (f) Information pertaining to 'as-built' condition of the items in the plant.

### 1.7.2. RECORD SYSTEM

The Record system provides details of identification, generation, indexing, filing, storing, maintenance, inspection and disposal of records and detailed procedures / instructions to cover the above.

Record system shall be established and maintained in accordance with written procedures and instructions. The system provides for identification, collection, indexing, filing, storing, maintenance and disposal of records. The records shall be generated as defined in detailed QA manuals / plans, procedures, specifications, tender documents, etc.

Generation, indexing, maintenance, control and preservation of all the records related to site construction activities shall be undertaken by respective site construction groups. Up-keeping and maintenance of all the manufacturing documents related to the equipment / materials arriving from manufacturers' shops viz., history docket, test certificates, shipping release documents, maintenance / service instructions shall be also the responsibility of respective construction agencies.

Non-Conformance Reports and Engineering Change Notices shall be controlled, registered and distributed by Field Engineering group.

Welding inspection reports, NDE reports, Fabrication reports, Erection / installation reports, Inspection / testing reports, procedures, Quality Assurance Plans and all other contract related documents shall be available with the respective construction groups.

Certain QA records such as Pre-Service Inspection baseline data shall be generated and maintained by site QA group.

The respective construction groups shall formulate their record and documentation control procedures.

#### 1.7.3. GENERATION OF RECORDS

The Design specification, Procurement documents, Commissioning documents, QA Plans indicate the records to be generated. The records are stamped and dated by authorized persons before storage. The records can be either originals or reproduced copies. However, all records shall be legible, identifiable with respect to item / relevant documents.

#### Construction Completion Documents

Construction Completion Certificates (CCCs) and System Transfer Documents (STDs) shall be prepared by the construction group and after concurrence by QA and FE submitted to Technical Services head of O&M group. These documents shall be prepared as per approved procedures.

#### 1.7.4. INDEX

Universal Subject Index (USI) system is followed for identification of records. In addition, the index system also indicates the type of record, location of record in storage area etc.

#### 1.7.5. RECEIPT CONTROL

Listing of records received, with respect to a check list of required records and certifying for completeness is carried out.

#### 1.7.6. RETENTION PERIODS

QA Records of the following categories are generated.

#### Permanent Records:

Records which shall be required for the entire life of the plant or for at least the life time of the particular item in order to meet one or more of the following objectives.

- a) To demonstrate capability for safe operation.
- b) To enable maintenance, rework, repair, replacement or modification of an item.
- c) To determine the cause of an accident or malfunction of an item.
- d) To provide reference data and document for in-service inspection
- e) To facilitate decommissioning.

#### Non Permanent Records:

Records, which shall be necessary to demonstrate accomplishment of the activity in accordance with the specification requirements shall be retained till the systems are transferred from construction to commissioning group.

The list of permanent / non-permanent records and their retention period shall be controlled in accordance with the approved procedure.

#### Temporary Records:

These are the records not falling in the above two categories, but generated during construction period to serve as evidence for satisfactory completion of the activities.

#### 1.7.7. DISPOSAL

Periodic reviews of the records are carried out in order to weed out unnecessary records and are disposed of by shredding/incineration after certification by authorized persons.

#### 1.7.8. STORAGE AND PRESERVATION

Storage of document and records shall be the responsibility of the respective construction group, till it is handed over for storage in a centralized facility.

A Centralized Document and Record Storage Facility shall be located and constructed so as to protect the records from possible damage or destruction by such causes as fire, flooding, insects, rodents and from possible deterioration by adverse environmental conditions such as temperature and humidity. This facility will have control procedures to enable the following:

- a) Access control for persons.
- b) Ready retrieval of any desired records
- c) Inspection and maintenance of records

Inspection of the storage facility shall be undertaken at least twice a year to ensure that,

- (i) The facility shall be adequate and the necessary environmental and other Protective measures are in effect.
- (ii) The records are updated regularly.
- (iii) Sampling inspection of records is done to check aspects such as receipt, control, retrievability and also to ensure that records are not deteriorating due to improper handling or storage practices.

For the purpose of storage of Documents and Records meant for the lifetime of the Plant, a permanent storage facility shall be established prior to commencement of commissioning activities.

#### 1.7.9. RECORDS INSPECTION

Inspection of the QA Records is carried out on continual basis by persons responsible for storage of records. These are also inspected by the QA group at least once in three months. Records of inspection are maintained.

The record storage facility is inspected at least once in a year to ensure adequacy and for up to date maintenance of the records. Sampling Inspection of the records is carried out to verify the record system.

## **CHAPTER - 2**

### **QUALITY ASSURANCE IN CIVIL CONSTRUCTION**

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## **QUALITY ASSURANCE IN CIVIL CONSTRUCTION**

### **2. 1.0 INTRODUCTION & SCOPE**

Quality Assurance of Civil construction is covered under this chapter and is to be read along with relevant Civil technical specifications as set out in the tender documents, specifications provided in the design drawings, BIS Standards and applicable drawings, etc. Reference to inspection, tests and special processes, procedures, standards, acceptance criteria and sampling plans are also indicated herein. The hold points beyond which the activity is not to proceed until the required inspections or tests have shown satisfactory results are well indicated in the Quality Assurance Plans.

### **GENERAL ASPECTS**

General aspects of Quality Assurance during the project construction phase viz. general requirements, various functions like management, performance, verification and corrective functions, records, organisation charts etc are covered in Chapter 1 of this manual.

### **2. 2.0 QUALITY ASSURANCE PROGRAMME OF CONTRACTOR**

Individual package contractors shall prepare their own Quality Assurance Manuals in line with this QA manual of BHAVINI.

Lists of QA procedures, Quality plans, QA formats, etc pertaining to this chapter are appended to this chapter. The contractor shall prepare the documents such as QA manuals, QA procedures, QA plans, QA formats etc and submit to construction group of BHAVINI for approval. The contractor shall perform the construction activities as per these approved documents.

### **2. 3.0 PREPARATION OF FOUNDATION**

Preparation of foundation prior to placement of concrete is a highly specialised work. To ensure satisfactory performance of the work, it is necessary to have a very stringent Quality Assurance programme.

The following Indian Standards, unless otherwise specified, will be applicable for carrying out various activities for preparation of foundation.

IS : 3764 - Safety code for excavation

IS : 4081 - Safety code for blasting and related drilling operations

IS : 6066 - Recommendations for pressure grouting of rock foundations in river valley  
Projects

IS :11309 - Method for conducting pull-out tests on anchor bars and anchor bolts.

### **2. 3.1 Excavation**

The excavation for various plant structures shall be carried out as per specification and approved drawings.

All loose boulders and semi-detached rocks, not directly in the excavation, but close to the area, shall be excavated and removed away. The excavation shall be carried out to such depths, lengths and breadths and profiles as shown in the drawings. Should any excavation be carried out beyond the specified limits, it should be filled up with the same type and class of materials as is proposed to be laid over the excavated portions, unless otherwise specified in the drawings / specifications.

Wherever needed, the sides of the excavation shall be timbered and shored up by a proper method. Such shoring shall be closed or open type depending upon the nature of the soil and depth of pit or trench. Excavation in hard rock shall be generally done by blasting and where blasting is not possible, the rock shall be removed by chiseling, wedging, picking, barring or by other approved methods.

### **2. 3.2 Blasting**

Blasting as required shall be carried out only by a competent and experienced supervisor and a licensed blaster, to be employed by the contractor. Wherever required, controlled blasting shall be adopted for reducing over break and for preventing damage to the rock.

Protective measures such as use of mufflers shall be resorted to prevent rock pieces from flying off. Non-electric blasting will be used for excavating the rock.

Procurement of blasting material, storage, precautions during and after blasting, limitations, maintenance of explosive magazine, transport of explosives, disposal of deteriorated explosives, etc. shall conform to the relevant specifications and directions of statutory authorities.

### **2.3.3 Dewatering**

Dewatering shall be carried out to ensure that the excavation and structure are free from water at all stages of construction and measures to exclude ground water and water from other sources such as underground streams, aquifers, springs, artesian, precipitation or infiltration from the surface floor etc. Dewatering shall be carried out thoroughly to maintain excavated portions reasonably dry by use of suitable pumps or bailing out water and slush manually or by other approved means.

### **2.3.4 Consolidation Grouting**

The number and pattern of grout holes shall be as per specifications and drawings. The equipment, pressures and proportion of grout mixes to be used shall also conform to the specifications and drawings.

The following reports shall be prepared at regular intervals to summarize important observations and data.

- a) A hole-wise data for drilling, water tests and inter-connections.
- b) A plan showing grout hole stages and grout intake.
- c) A 'L' section showing drilling stages and grout intake, in case of curtain grouting.

### **2.3.5 Inspection / Testing of Soil / Rock under Foundation**

All excavated areas shall be cleaned, debris removed, and the pits trimmed to exact shape and sizes before any further work such as placement of mud mat and reinforcement is commenced. Some of the important tests to be carried out before clearance of strata for constructing foundation are:

- Static Plate Load Test
- Standard Penetration Test
- Seismic Cross Hole Test
- Universal Jacking Test
- Pressure Meter Test
- Laboratory Test
- Lithograph
- Block Shear Tests.
- Rock Deformation Tests.

Cyclic Plate Load Tests.

Block Vibration Tests.

Water Loss Tests

The above tests shall be conducted as per standards wherever so specified in the drawings by designers.

#### **2.4.0 PRE-CONSTRUCTION VERIFICATION**

Pre construction verification shall include the following :

- a) Materials / Ingredients used in production of concrete,
- b) Materials used in construction and
- c) Construction processes

#### **2. 5.0 CONCRETE AND ITS INGREDIENTS**

To realize, the uniform quality of concrete of required strength and durability to assure satisfactory service through out the intended operating life of the structure, due qualification of ingredient materials, method of production, placement, compaction, finishing and curing are carried out. A typical flow chart showing various factors leading to production of good uniform concrete is shown in page - 82 .

Designing of concrete mixes is undertaken to assure an accurate guide for selecting the best combination of ingredients so as to achieve the desirable properties of concrete. A schematic representation for procedure of concrete mix design is shown in page-83.

All laboratory tests relating to concrete ingredients will be carried out by agencies as indicated in the tables. The responsibility for production and placement of quality concrete is rested with the contractor. In general, testing is carried out in the laboratory at site by the contractor and approved by QA (Construction) group. The tests, which cannot be conducted in this laboratory, are arranged in other qualified laboratories with the approval of QA (Construction) group.

The following concrete ingredient materials are procured and inducted into works on their complying with applicable QA plans.

- a) Cement
- b) Coarse Aggregate (both normal and heavy)
- c) Fine aggregate( both normal and heavy)

- d) Water
- e) Concrete Admixture
- f) Steel shots
- g) Hematite, Magnetite
- h) Ice

### **2. 5.1 Protection of Concrete Ingredient Materials**

The stock piles of aggregates will be formed so as to prevent segregation. The deposition and removal there from will be done in such a manner so as to maintain the uniformity of the stock pile. The side slope of stock piles of aggregate shall be kept flatter than the angle of repose to prevent accumulation of coarse material at the bottom of the slope.

Admixture or such additives shall be used within their shelf life of one year as specified by the manufacturer. The containers shall be stored on a raised platform and protected from sun, rain, wind and moisture. The materials and storage places shall be periodically inspected. The lids of the container shall be in properly sealed condition all through, so that entry of moisture/rain water etc. are avoided and contamination is prevented.

### **2. 6.0 CONSTRUCTION MATERIALS**

The following major construction materials are procured and inducted into works on their complying with applicable QA plans.

- a) Reinforcement Steel
- b) Structural Steel
- c) Water stopper - PVC, MS , GI & Copper
- d) Polysulphide Caulking Compound
- e) Epoxy Paint
- f) Clear Epoxy
- g) Surface Retarder
- h) Neoprene Pads
- i) Expanded Polystyrene Boards
- j) Integral Cement Water Proofing Compounds
- k) Copper Conductors

## **2. 7.0 CONSTRUCTION PROCESS**

Mock Ups, if any are identified and carried out well in advance of the construction activities.

Construction process shall include the following:

- a) Laying, placing and binding of reinforcement
- b) Form Work
- c) Fixing Of Embedded Parts
- d) Production, Transportation of Concrete
- e) Placement, compaction and curing of Concrete
- f) Grouting Operation
- g) Inspection and Testing activities
- h) Repairs if any,
- i) Acceptance of Test / Inspection results

### **2.7.1 Laying, Placing and Binding of Reinforcement**

Reinforcement bars are bent in compliance with IS 2502. Reinforcement shall be laid in sequential layers following approved drawings and within the tolerances given in IS 456. Laps shall be provided strictly as per the drawings. Mortar blocks of specified grade and size shall be tied for providing cover to reinforcement bars.

### **2. 7.2 Form Work**

Forms shall conform to the shapes, lines, grades and dimensions including camber, grooves and projections as called for in the drawings. Ample struts, walers, braces, etc. shall be used to hold the forms in proper position without any distortion whatsoever until the concrete has set sufficiently to permit removal of forms. Form work shall be rigid and strong enough to withstand any effect of vibration practically without any deflection, bulging, distortion or loosening of its supports. Forms will be braced, strutted, propped and so supported that it shall not deform under weight and pressure of the wet and hardened concrete, and also due to the constructional facilities.

### **2.7.3 Fixing of Embedded Parts**

Embedded parts shall be aligned within the tolerance limits indicated in the construction drawings. In addition, specific critical EPs shall be aligned to even closer tolerances as per the interfacing system requirement. EPs shall be securely fixed in such a manner that during concrete placement process these are not subjected to any disturbances.

### **2.7.4 Placement of Concrete**

Concrete of grade as specified in the drawings and produced in a systematic and established manner at batching plant shall be transported to the pouring point and placed in the pours as desired by the site based on site conditions. Care shall be taken in ensuring the placement in a systematic way through an approved construction methodology only at the design basis rate per hour and so as to avoid any defects such as honey comb, under / over vibration, bleeding, cold joint etc.

### **2.7.5 Curing**

Curing shall be carried out as specified. Inspections should be performed throughout the specified curing period to verify that the curing requirements are adhered to. Such inspection shall cover:

- a) Moisture control
- b) Temperature control
- c) Use of curing compounds and
- d) Retention time of shoring and form work

### **2.8.0 POST CONCRETING INSPECTION**

All the structures shall be visually inspected immediately after deshuttering. This post concreting inspection shall be carried out by the contractor. Where required, these will be done jointly by BHAVINI's Engineer (Civil), Engineer (QA) and Contractor's Engineers. For all pours involving concrete quantity more than 50 Cu.m, a Post Concreting Inspection format shall be used for recording these findings. All defects such as honey combing, bulging and non-setting shall be recorded preferably giving locations and dimensions, as far as possible. Rectification shall be done as per the procedures approved by BHAVINI. All the repairs shall be properly documented in the post concrete inspection formats.

## **2. 9.0 FINISHING AND REPAIR**

Inspection shall be performed to verify that specified finishes, like wood float, steel trowel or as cast are obtained. Any indications such as under vibrations, voids, improper bonding or contamination such as at construction joint shall be explored by physical removal of concrete if necessary to determine their extent and appropriate repairs made and documented.

## **2. 10.0 POST INSTALLATION TESTING OF CONTAINMENT STRUCTURES**

Post installation testing of containment structure shall be carried out thoroughly in stages as per required standards, specifications and as per the approved test procedure. During such test, if any leakage/defects in the surface of concrete containment structure is noticed, such leakage and defects shall be rectified to the satisfaction of BHAVINI.

## **2. 11.0 LISTS OF DOCUMENTS**

- List of QA manuals
- List of QA procedures
- List of standard QA charts
- List of standard QA plans
- List of QA formats
- Flow chart showing production of good uniform concrete
- Schematic diagram for designing of concrete mix

**Note :** The above lists are only indicative. Additional Manuals, Procedures, Methodologies, Charts, QAPs and Formats as required shall be formulated by the contractor and approved by BHAVINI.

## LIST OF QUALITY ASSURANCE MANUALS

1. QA Manual for procurement, manufacturing and construction issued by BHAVINI.
2. QA Manuals issued by contractors.

## LIST OF QA PROCEDURES

### A] Civil Works :

1. Procedure for excavation in rock by blasting.
2. Procedure for consolidation grouting of foundation rocks.
3. Procedure for backfilling and compaction.
4. Procedure for Qualification of Admixture.
5. Procedure for placement of concrete for major pours in NICB raft, RCB roof, TG mat, TG block & stack.
6. Procedure for placement of concrete by pumping.
7. Procedure for Green cutting of concrete surface.
8. Procedure for Cement Based Treatment.
9. Procedure for slicing, welding, coupling of Re-bars.

### B] Quality Control/ Concrete Testing Laboratory works

- 1 Procedure For Compressive Strength Test of Concrete Specimens
- 2 Procedure For Flexural Strength of Moulded Flexure Test Specimens
- 3 Procedure For Determining Setting Time Of Concrete
- 4 Procedure of Test For Split Tensile Strength of Concrete Cylinders
- 5 Procedure For the Modulus of Elasticity by means of Compressometer
- 6 Procedure for Calibration of Compression Testing Machine
- 7 Procedure for Determination of Workability using slump cone
- 8 Procedure for Determination of Air Content of Freshly Mixed Concrete
- 9 Procedure for Determination of Unit Weight of Freshly Mixed Concrete
- 10 Procedure for Determination of Bleeding of Concrete
- 11 Procedure for Casting the Cubical, Cylindrical & Beam Moulds
- 12 Procedure for Determination of Aggregate Crushing Value
- 13 Procedure for Determination of Aggregate Impact Value
- 14 Procedure for Determination of Aggregate Abrasion Value

- 15 Procedure for Determination of Flakiness Index of Coarse Aggregate
- 16 Procedure for Determination of Elongation Index of Coarse Aggregate
- 17 Procedure for Determination of Soundness of Aggregates
- 18 Procedure for Determination of Specific Gravity of Fine Aggregate
- 19 Procedure for Determination of Specific Gravity of Coarse Aggregate
- 20 Procedure for Sieve Analysis of Coarse and Fine Aggregate
- 21 Procedure for Determination of Consistency of Standard Cement Paste
- 22 Procedure for Compressive Strength Test of Cement Specimens
- 23 Procedure for Determination of Specific Gravity of Cement
- 24 Procedure for Determination of Initial and Final setting Times of Cement
- 25 Procedure for Determination of Fineness by Specific Surface by Blaine Air Permeability Method
- 26 Procedure for Determination of Soundness of Cement by Lechatlier Method
- 27 Procedure for Determination of Soundness of Cement by Autoclave Method
- 28 Procedure for Dimensional check of Bricks
- 29 Procedure for Determination of Water Absorption of Bricks
- 30 Procedure for Determination of Compressive Strength of Bricks

## STANDARD QUALITY ASSURANCE CHARTS

The Quality Assurance Standard Charts will be compiled indicating the requirements of relevant standards and specifications, to be adhered to.

- QA Chart No. 1     Grading of Coarse aggregate
- QA Chart No. 2     Grading of Fine aggregates
- QA Chart No. 3     Physical Requirement for Admixture

## LIST OF STANDARD QUALITY ASSURANCE PLANS

The Quality Assurance Plans for the following will be compiled indicating the requirements of relevant standards and specifications, to be adhered to. Details of the frequency of verification and agencies responsible for performance and verification will also be indicated. The characteristics of items / activities to be inspected & tested and applicable codes / standard tables giving QA requirements will be indicated. Survey of probable sources to assess adequacy of supply of material to satisfy specified quality with references to codes, standards and specification requirements will also be indicated.

1. Excavation work.
2. Dewatering
3. Cement
4. Coarse and Fine Aggregate (normal & Heavy)
5. Mixing water/ice (crushed)
6. Concrete Admixture
7. Procurement, installation etc. of Aggregate processing, batching and mixing plant & chilling plant etc.
8. Production of concrete
9. Transportation of concrete
10. Form work/shuttering
11. Placement of concrete
12. Sampling and Testing of Concrete
13. Concrete by pumping
14. NICB raft
15. Repair of concrete
16. Grouting / Dry pack
17. Backfilling
18. Reinforcement bars for concrete
19. Welding/ splicing/ mechanical coupling of Re bars
20. Placement fabrication of concrete reinforcement bars

21. Procurement and erection of Liner
22. Procurement & fabrication of Structural steel
23. Erection of Structural steel
24. Procurement and fabrication of Embedded parts
25. Erection of Embedded parts
26. Procedure for treatment of interference of lugs with Re bars.
27. Water-proofing / Insulation of underground structures
28. Flooring
29. Stone / Brick masonry and plastering
30. Procurement, storage and installation of grouting material
31. Procurement of paints and painting
32. Painting of pipes pipe supports, equipment and Misc. Structures in Main plant area
33. Calibration requirement of instruments

## QUALITY ASSURANCE FORMATS

Quality Assurance formats will be used indicating the requirements of relevant standards and specifications, to be adhered to. The QA formats are distinguished as site formats and lab formats based on their service area.

### **QA Site Formats:**

The following Quality Assurance formats are used for maintaining QA records at Site. These forms are filled at appropriate places based on Indentor, Executioner etc. These formats shall form a part of respective procedures to be prepared by the contractor for executing various activities.

### **Excavation / Grouting Formats:**

Blasting activity

Curtain / Consolidation Grouting

### **Concrete Pour Inspection Formats:**

Concrete Pour Clearance Card

Post-Concrete Inspection Card

Bore hole-drilling Report

Water – Loss Test

Consolidation Grouting Report

Hydro Test of Grout Tube

### **QA Concrete Testing Lab / Batching Plant Formats**

Concrete Specimen Testing

Determination of Modulus of Elasticity by Compressometer

Calibration of Test Instruments

Coarse Aggregate Test Report

Fine Aggregate Test Report

Soundness Test Report of Coarse Aggregate

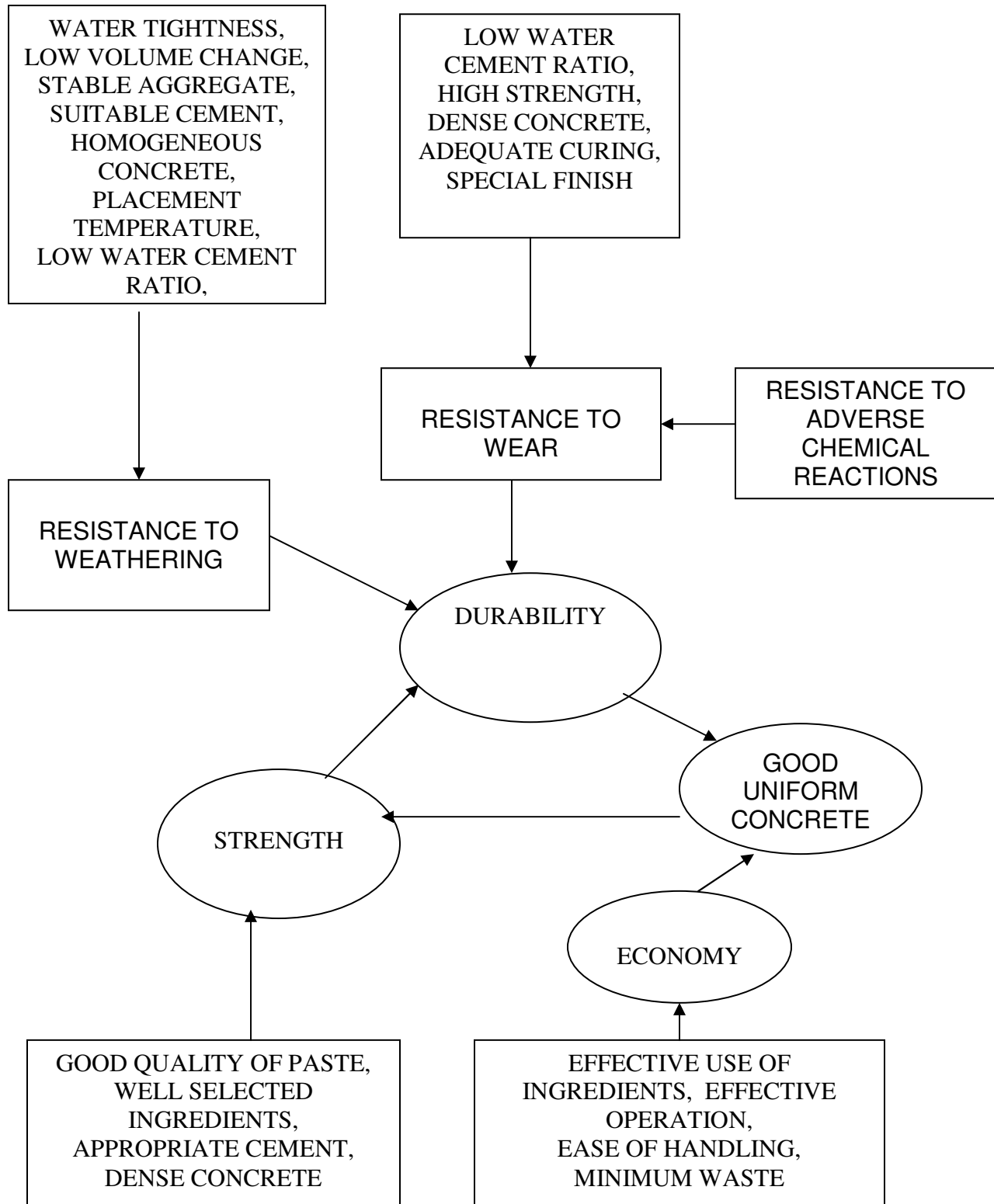
Soundness Test Report of Fine Aggregate

Soundness, Specific gravity & Specific surface Test of Cement

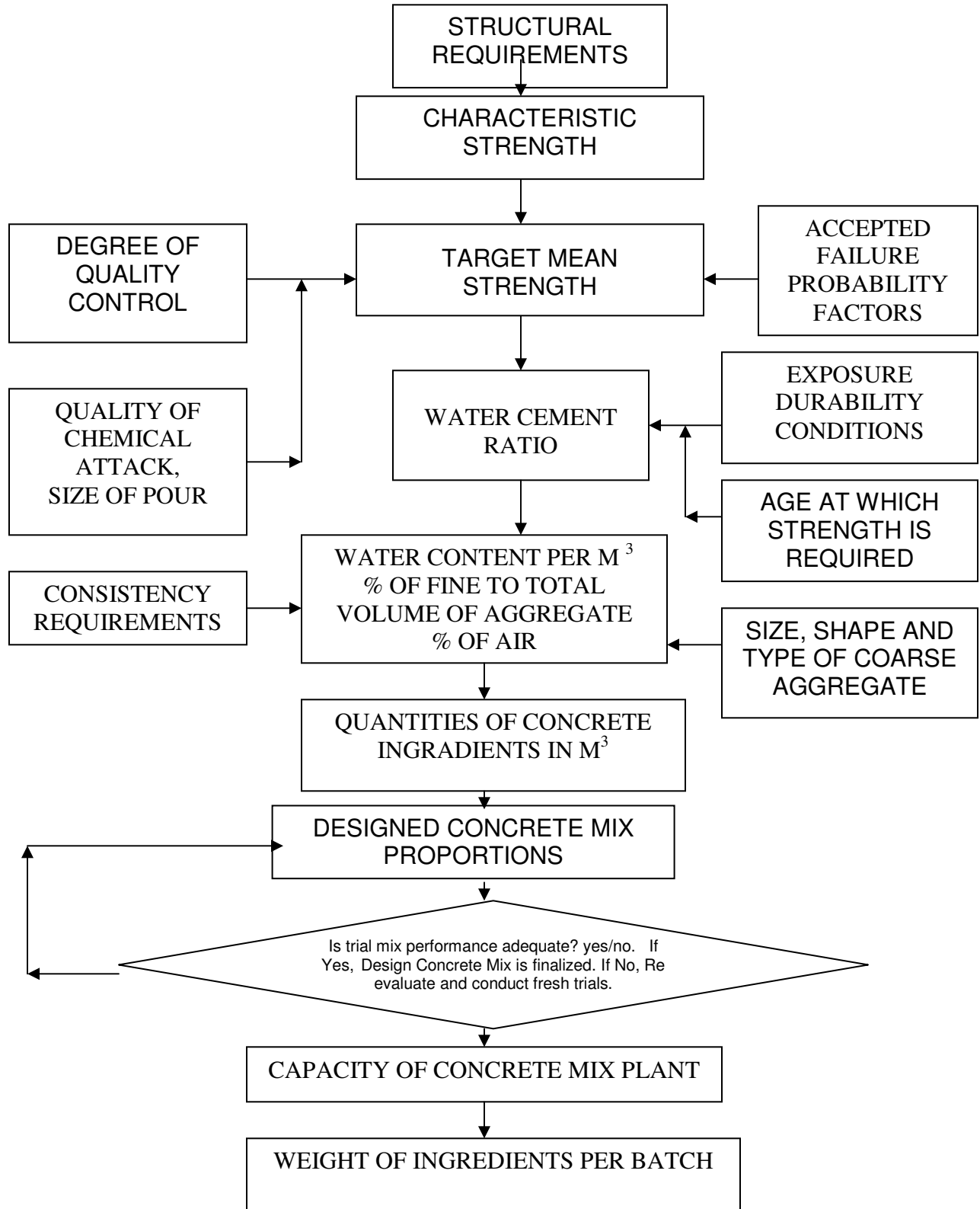
Cement Test Data (Register)

Cement Test Report  
Monthly Cement Test Results Report  
Concrete Specimen Test report  
Concrete Mix Design  
Concrete Quantity Report  
Concrete Strength Report  
Brick Test Report  
Soil Test Report  
Reinforcement Unit Weight Test Report  
Testing of Coarse Aggregate Sieve Analysis (40 mm)  
Testing of Coarse Aggregate Sieve Analysis (20 mm)  
Coarse Aggregate Flakiness Index  
Coarse Aggregate Elongation Index  
Testing of Coarse Aggregate  
Testing of Fine Aggregate Sieve Analysis  
Testing of Fine Aggregate  
Testing of Admixture  
Heavy Aggregate Specific Gravity Test Report  
Calibration of Weighing Scales  
Concrete Requisition  
Concrete Starting Slip  
Concrete Batch Weight Report  
Concrete Despatch Slip  
Concrete Specimen Sample Data  
Concrete Placement Records  
Cover Block Casting Details  
Permeability Test on Concrete Specimen  
Note: These forms are filled at appropriate places based on indentor, executioner etc.  
viz. site batching plant, mixing plant and testing laboratory.

**FLOW CHART SHOWING PRODUCTION OF  
GOOD UNIFORM CONCRETE**



**SCHEMATIC DIAGRAM FOR DESIGN OF CONCRETE MIX**



## **CHAPTER - 3**

### **QUALITY ASSURANCE IN MECHANICAL CONSTRUCTION**

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## **QUALITY ASSURANCE IN MECHANICAL CONSTRUCTION**

### **3. INTRODUCTION & SCOPE**

This chapter describes the salient aspects of the Quality Assurance programme and guidelines on process control activities during construction, installation, inspection and testing of mechanical works carried out by the following construction groups and the contractors under their control:

- Nuclear Steam Supply System (NSSS) group
- Piping group
- Balance of Plant - Mechanical (BoP-Mech) group

All works are executed as per technical specifications, design drawings and applicable codes and standards. The control points for various quality related activities are brought out in the respective Quality Assurance Plans.

### **GENERAL ASPECTS**

General aspects of Quality Assurance during the project construction phase viz. general requirements, various functions such as management, performance, verification and corrective functions, records and organization charts are available in Chapter 1 of this manual.

#### **3.1.0 PROCESS CONTROL ACTIVITIES COMMON TO CONSTRUCTION, INSTALLATION, INSPECTION AND TESTING WORKS UNDERTAKEN BY NSSS, PIPING AND BOP-MECHANICAL GROUPS**

Careful and detailed planning, execution and documentation shall be undertaken to assure that specified quality shall be imparted to the works executed by each of the three groups mentioned above. Broadly these activities involve following:

- Pre-installation verification ( as per manufacturing end documents)
- In-process verification (during construction)
- Post-installation verification (after construction and during commissioning)
- Preservation of installed systems (after construction and commissioning)

#### **3. 1.1 Pre-installation verification**

Equipment / materials received from vendors' shops and manufactured at plant site shall be required to be installed at plant site. All mechanical fabrication activities at site generally involve following stages:

### **3.1.1.1 Manufacturing of Equipment / Systems (Piping)**

- i) Prior to commencement of fabrication activities, detailed manufacturing process sheets, assembly procedures and Quality Assurance Plans (QAP) shall be prepared based on applicable approved drawings, specifications, codes and standards and shall be approved by the Purchaser. The QAPs detail different stages envisaged in the manufacture of the equipment, viz., material inspection, procedures and personnel qualifications, consumables, layout and cutting plan, dimensional measurements, non-destructive examination, hydro static test / pneumatic tests, surface treatment such as degreasing, pickling and passivation, helium leak testing, painting etc as per the specification requirements. The QAPs also specify review, witness and hold points assigning responsibilities to manufacturer, supplier, works contractor or their authorised representatives, QA (Construction) group, concerned project execution groups at site. Detailed procedures, checklists and technique sheets shall be formulated, reviewed and approved at appropriate levels for all relevant activities such as manufacturing, welding, non-destructive examination, stress relieving, hydro static test/ pneumatic test, surface treatment such as degreasing, pickling and passivation, helium leak testing, painting etc., listed in QA Plans.
- ii) On approval of QAP and fabrication documents, the equipment shall be taken up for fabrication. Manufacture and stage inspections shall proceed as per the approved QAP and manufacturing documents. In the event of any modifications desired by manufacturers / BHAVINI, QAP and manufacturing documents shall be revised accordingly and approved prior to implementing them.
- iii) In the first stage, raw material inspection shall be undertaken. Test certificates shall be correlated and wherever correlation is not possible or when test certificates are found inadequate, necessary tests as required by the relevant specification shall be carried out.
- iv) Alignment, fit-up, welding and stage NDE activities shall be carried out. Care shall be taken to avoid / minimize distortion in the weldment. Any discontinuity revealed during non-destructive examination shall be evaluated and if the discontinuities are beyond acceptable limits, defects shall be repaired. All the NDE specified for original requirements shall be repeated after repair for the repaired area to ensure that the discontinuities, if any, are within acceptable limits.

- v) Stress relieving shall be carried out, as required, as per the approved procedures. Specified NDE shall be carried out after stress relieving as per the approved procedures. Well-trained, qualified and certified personnel shall carry out NDE and other relevant inspection activities. Records of qualified and certified inspection personnel shall be maintained by manufacturers and shall be produced as and when required by BHAVINI for necessary verification.
- vi) On completion of manufacture, the components shall be assembled into sub-assemblies and final assembly and also inspected in accordance with the approved assembly procedures.
- vii) Adequate nuclear clean condition shall be maintained as per the specified class A, B or C for the respective components at manufacturing sites. Special precautions shall be taken in case of critical equipments. Segregation between carbon steel and stainless steel manufacturing / handling areas shall be strictly maintained to prevent possible iron/ carbon contamination in stainless steel.
- viii) After checking final dimensions, hydro static / pneumatic / helium leak tests shall be carried out as per the relevant specifications / procedures. Degreasing, pickling, passivation, helium leak testing and painting shall be carried out after hydro static / pneumatic tests as per the specification requirements.
- ix) As built drawings, manufacturing procedures and records of verifications including material test certificates, dimensional inspections, reports of all destructive and non destructive examinations, weld inspection and test reports shall be documented with proper serial number and date for each system and assembly.
- x) N-S and E-W axes or any other relevant orientations and directions shall be marked on components and equipments as well as on fully assembled equipment, as per requirements, which shall be used in defining and achieving orientation during assembly / installation at site.

#### **3.1.1.2 Checks carried out prior to Installation**

Prior to taking up installation work, checks shall be undertaken to ensure correctness of supply of equipments and materials.

- i) Shipping release and material test certificates/ Test Certificates shall be available for the items purchased from the market such as pipes, structural steel, fasteners etc.

- ii) Equipments manufactured and assembled at manufacturers shop and supplied, shall have history docket / final / end documentation viz., material test certificates/test reports, shipping release and documents available at site.
- iii) Duly qualified and documented procedures for installation / processes and other applicable documents shall be available.
- iv) Identity of the items shall be duly established with respect to approved construction documents, viz., drawings / equipment lists / specifications etc.
- v) It shall be ensured that all manufacturing and assembly work on the item inclusive of any site work as indicated in non-conformance reports / history docket / shipping release has been completed and the item cleared for installation.
- vi) It shall be ensured that interference due to a particular equipment or activity does not affect other equipment installation work.
- vii) It shall be ensured that the item is free from physical damage, corrosion, contamination and it is cleaned in accordance with specifications. Care shall be taken to ensure that the cleaning solutions and other items used shall not be detrimental to the material.
- viii) All personnel employed in installation / erection, inspection and testing works shall be qualified / certified by Construction Directorate as required.
- ix) Jigs, fixtures and equipment, tools and instruments for special processes shall be duly qualified and available for use.
- x) All instruments, gauges used for installation, inspection and testing shall be duly calibrated.
- xi) Valves shall be tested and relief valve pressure settings identified and checked.
- xii) All material handling / lifting equipments shall be duly tested, maintained and documented.
- xiii) Installation area shall meet the specified requirements, viz.,
  - Cleanliness including provision of dust free enclosures, temperature and humidity control wherever applicable as per the relevant class of nuclear clean condition.
  - Protection from adjacent construction activities, as required.
  - Protection from inclement weather and other adverse ambient conditions,
  - Provision for permanent and temporary supports,
  - Measures to control distortion or dimensional deviations,

- All precautions for safety of personnel, equipment being installed or nearby area or equipment.
- xiv) Non-conformance, if any, has been resolved and documented.

### **3. 1.2 In-Process Verification**

Inspection of work areas in progress shall be performed to verify that equipment / systems shall be located, erected, installed, assembled and connected in accordance with the specified requirements. The inspection includes verification of following:

#### **3.1.2.1 Verification of Work Area**

- i) Cleanliness / housekeeping of work area as per the relevant class of nuclear clean condition (Existence of barriers and protective covers and effective housekeeping) to ensure that equipment and components will not be damaged or contaminated as a result of personnel traffic, weather or adjacent construction activities such as concreting, chipping, jack hammering, welding and acid cleaning).
- ii) Clearances and dimensional tolerances available for handling and installation of materials, equipments/systems.
- iii) Completeness of pre-requisite activities.

#### **3.1.2.2 Verification of Equipment / System during Installation**

During installation of equipments / systems following aspects shall be verified:

- i) Physical integrity of equipment including tightness of connection and fasteners, fluid level and pressure, leak tightness, condition of protective coating, protective covers on threaded and machined surfaces.
- ii) Leveling, alignment and orientation of embedded parts, components, supports to be connected to conform to drawing requirements. Critical equipment shall be aligned in close tolerances with optical alignment instruments. Such critical equipment include reactor assembly components namely safety vessel with thermal insulation, main vessel integrated with cooling pipes, core catcher and core support structure, thermal baffles, grid plate, spherical headers, inner vessel with stand pipes, roof slab, shielding assemblies, large rotatable plug, small rotatable plug, control plug, intermediate heat exchanger, primary sodium pump, DHX, DND, control and safety rod drive mechanism, diverse safety rod drive

- mechanism, FFIM and in-vessel transfer machine, IFTM, AHX and other equipments such as steam generators and secondary sodium pumps.
- iii) Freedom of moving parts such as valves, stroking and actuation and rotation of prime movers.
  - iv) Installation of supports, hangers, restrainers, dampers and shock absorbers.
  - v) Limit switches, interlocks and mechanical stops.
  - vi) Greasing and lubrication points and access to these points.
  - vii) Strainers
  - viii) Electrical circuit controls, relays.
  - ix) Existence of end caps on pipes, tanks equipment to prevent ingress of extraneous material into the system.

### **3.1.2.3 Monitoring / Verification of Activities viz., Welding, Mechanical Joints, Surface Preparation and Painting**

- Verification of welding filler metal.
- Welding process control checks such as welding procedure qualification, welder qualification, dimensional fit up, sequence of welding, accessibility for inspection, calibration of welding machine, electrode baking, calibration of ovens, stage inspection, purging, removing of purge dams upon completion of welding, removal of cleats, etc.
- Preheat and post weld heat treatment
- Examination and testing of welds by Non-Destructive Examination such as Visual Examination (VE), Penetrant Examination (PE), Magnetic Particle Examination (MPE), Radiographic Examination (RE), Ultrasonic Examination (UE), Leak Testing (LT), as required by relevant specifications.
- Identification of items, components, equipment, joints.
- Alignment of flanges and torqueing of bolts.
- Cleanliness of systems, inside and outside.
- Precaution in handling and storage of stainless steel items to prevent contamination of surfaces, identification of grinding wheels for use on SS/CS materials, segregation of CS/SS material.

### **3. 1.3 Post Installation Inspection and Verification**

Inspection of installed systems shall be performed to ensure compliance with the specified requirements. Installed equipment and systems shall be tested to demonstrate

that the installed equipment and systems perform in accordance with design and performance requirements. Each installed system shall be tested starting with equipment in isolation, sub-systems and finally the complete integrated system in accordance with the specification / approved procedures. The requirements to be followed are given below in brief:

### **3.1.3.1 Cleaning of Systems**

- i) Inspection shall be performed to verify that installed systems and components shall be cleaned, flushed and conditioned as per approved procedures. These procedures shall contain details such as sequence of operations and methods for filling, venting, fluid circulation, draining, flushing, equipment isolation, location of other temporary equipment, piping, valves, blind flanges, concentration, temperature and duration of chemical conditioning operations, detection of foreign bodies in system and components.
- ii) The cleaned systems shall be preserved as per approved procedures.
- iii) Verification for cleaning includes the following:
  - Removal of temporary, used, unwanted parts from the system to facilitate flushing and reinstallation of component items and parts.
  - Installation and removal of temporary strainers blind flanges and piping.
  - Isolation of sensitive instrumentation.
- iv) Acceptance data specimen or progressive samples, as per pre-defined acceptance criteria.

### **3.1.3.2 Integrity and Leak Testing**

All the components of the system shall be checked for completeness of construction / installation by physical checks and verification of records for acceptance prior to pressure and leak testing and performance tests. For every circuit / components to be tested, a test scheme shall be got approved from BHAVINI and a circuit release report for leak testing shall be signed by the contractor, Construction Directorate, FE and QA (Construction) group before taking up pressurization. Pressure testing shall be carried out as per approved procedure. The type of pressure test carried out at site shall be pneumatic test, hydro static test, helium leak test as per the requirements of relevant specifications, and application.

### **3.1.3.3 Pneumatic / Hydro static Testing**

Pneumatic / hydro static testing shall be carried out to examine the following

- i) All site-fabricated joints (welded, threaded, mechanical, flanged) including weld attachments to system boundaries, weld seams of longitudinal welded elbows.
- ii) All areas of pipelines etc. where temporary attachments have been provided. However, complete pipeline shall be checked for leakage.
- iii) Joints of equipment which are opened at site for the purpose of testing, erection
- iv) Equipment not tested at manufacturers' works.
- v) Region of high stresses, such as region around openings and thickness transition sector.
- vi) Valve glands, leak off points etc.

### **3.1.3.4 Helium Leak Testing**

Helium leak testing (HLT) shall be carried out as per the approved test scheme and procedures. Helium leak testing shall be carried out after successful completion of pneumatic / hydraulic test as mentioned above. Following areas of relevant circuits / components shall be covered in HLT when the same shall be specified:

- i) Site fabricated joints (welded, threaded, mechanical, flanged including O-rings) including weld attachments to system boundaries.
- ii) Joints of equipment which were opened at site for testing and erection purpose.
- iii) Equipment not tested at the manufacturers' works.
- iv) Valve glands, leak off points.
- v) Instrumentation tubing swage joints and other mechanical joints.

### **3.1.3.5 Inspection Requirements during Pressure and Leak Testing**

Inspection shall be carried out to verify the following aspects during pressure and leak testing of mechanical systems and components:

- i) Specified pressure test cycle, temperature, test fluid chemistry shall be followed / maintained.
- ii) Components external to test boundary shall be protected to prevent probable damage due to inadvertent over-pressurization.
- iii) Pressure relief devices shall be set to prevent system over pressurization.
- iv) Piping, equipment and other supports shall be protected from hydro static loads.

- v) Provision for protection of personnel and equipment.
- vi) Provision of proper drain points, vent points.
- vii) Proper depressurization method followed.
- viii) The completed system or sub-system shall be checked to verify that:
  - All parts of the system are correctly installed as specified.
  - Control vales, relief valves, dampers, rotating equipment are operating correctly in proper direction and to the specified extent.
  - On-line instrumentation are installed correctly with respect to flow directions and other parameters.
  - The test data recorded during the pre-operation tests are analyzed and evaluated with reference to acceptance standards and operation limits. Non-conformances observed in the equipment, items and systems with reference to such standards and limits, shall be rectified and tests re-conducted to achieve specified performance. A detailed report of all observations and analysis shall be prepared for all such test results to form part of final documentation.

#### **3.1.4 Preservation of Installed Equipment and Systems**

- i) All equipments and systems installed and fully tested but not put into operation due to non-availability of connected systems or equipment shall be preserved with proper protection. Examples of such equipment and systems particularly of importance shall be heat exchangers, pipe lines, tanks, pressure vessels and turbo generator.
- ii) All such installed equipments shall be duly preserved, protected and maintained as per applicable procedures approved by BHAVINI, for ensuring their availability as required during system commissioning stages.
- iii) The preservation procedures for various equipments and systems shall be got approved from BHAVINI.

#### **3.1.5 Procedures**

All execution works and activities including verification activities shall be performed following duly approved procedures, quality plans and checklists etc. and all documents shall be duly filled up with execution data, authenticated and maintained. Prior to

commencement of works execution / verification activities, the following applicable procedures, shall be submitted and got approved from BHAVINI:

- Welding procedures.
- NDE procedures.
- Procedures for training and qualification of personnel.
- Erection / installation procedures for piping, reactor components and mechanical equipment.
- Pressure / leak testing procedures.
- Procedure for handling of critical equipment / components.
- Procedure for issue and control of raw material.
- Procedure for storage of critical components
- Manufacturing procedures
- Cleaning procedure
- Calibration procedures for all instruments
- Inspection procedure

Above list is only indicative and of generic nature. Additional procedures as required shall also be submitted and got approved from BHAVINI.

### **3. 1.6 Qualification of Equipment and Personnel**

#### **3. 1.6.1 Qualification of Equipment / Consumables**

The equipment / consumables, as listed below shall be qualified prior to being put to use.

- Tube welding equipments
- Welding equipments
- Stress relieving apparatus
- Optical alignment instruments
- Critical installation tools
- Inspection and measuring tools
- Welding consumables
- NDE consumables

Qualification of consumables and equipment shall be undertaken in accordance with the relevant procedures assuring that all the measuring and test equipment have the range,

type, condition and accuracy to achieve and maintain conformance with the specific requirements. All such equipment shall be adjusted, maintained and calibrated as per procedures. Records of adjustment, maintenance and calibration with their validity shall be maintained, and equipment suitably identified and marked.

### **3. 1.6.2 Training and Qualification of Personnel**

**Refer Para 1.3.4.**

### **3. 1.7 Pre-Service Inspection**

Pre-service inspection shall be performed to collect the base line data on following equipments / systems:

- i) Heat exchanger tubing's shall be tested by eddy current testing (viz., steam generators, re-heaters, condensers etc.)
- ii) Ultrasonic examination of weldment of equipment viz., dissimilar metal weld between main vessel and roof slab, secondary sodium piping system critical welds, dissimilar metal welds between steam generators and secondary sodium piping, primary pump flywheel etc, shall be carried out.
- iii) Any other examination method specified for other equipment as per specification / ISI programme.

Actual equipment / systems to be inspected and the extent / type of base line data collection shall be detailed in ISI / PSI Manual for BHAVINI. Such data collected shall consist of all recordable indications observed clearly mentioning the location with respect to a known reference structural member / equipment.

The data shall be generated in line with in-service inspection programme and these data shall be compiled and report issued as permanent records. Corrective actions, as required, shall be undertaken.

### **3. 1.8 Analysis and Evaluation of Inspection and Test Results**

Procedures shall be established for processing inspection and test results and for their analysis and evaluation. These procedures shall include the reference of codes, standards, specifications or other special requirements and their limiting values. The data processing procedures shall provide for preliminary evaluation to determine validity of the results and the appropriateness of continuing the inspection or test.

The test results shall be analyzed and evaluated to verify the completeness of the results, inspection and test objectives, conformance with the acceptance criteria limit for each activity being completed for equipment and systems. Reports shall be prepared for every inspection and testing activity covering the test results, their analysis and evaluation and recommendations, if any.

### **3. 1.9 Radiographs**

All the works of manufacturing / erection / testing shall be completed and final acceptance of the systems / sub-systems / components shall be confirmed by issue of construction completion certificates (CCC), to include the radiographs also.

List of joints and radiographs shall be prepared CCC wise. The individual radiograph (sheet) shall be kept in a folder and all the radiographs of a joint shall be kept together in a separate folder (termed as joint folder). All the finally accepted films of a joint shall be kept on top in every joint folder. Remaining films of retake, re-shoot, repair etc. shall be kept in the sequence of order from bottom. The joint folders in turn shall be kept in an envelope and the details of the radiographs shall be recorded on the envelope.

The envelopes containing radiographs shall be handed over to Quality Assurance (Construction) group. The QA group shall check the quality, identification, and sequence of stacking of radiographs before accepting the same. In case of non-availability, or poor quality of radiograph of a joint, another acceptable radiograph shall be taken on the joint. The full stock of radiographs shall be checked by QA (Construction) group at the time of clearance of equipment / pipeline for leak / pressure testing. This will help in timely re-radio graphing the joints in case of defaced / missing radiographs.

### **3. 1.10 Fabrication / Machining Jobs**

Fabrication / machining works to be undertaken in site mechanical workshop shall be exercised in the following manner for the components forming part of plant's permanent system. Drawing nos., material specification and NDE requirement shall be clearly mentioned before carrying the work. For fresh manufacturing / repair of permanent plant items, detailed information shall be furnished in the specified formats. In case of non-availability of drawing, a sketch showing all relevant details duly checked by concerned Engineer and approved by the Field Engineer shall be attached with the manufacturing order.

### **3. 2.0 REQUIREMENTS, RESPONSIBILITIES AND QUALITY ASSURANCE OF NSSS WORKS**

NSSS group shall ensure that all works are executed meeting the specified requirements. QA group of respective manufacturing / works contractors will prepare QA documents such as QA procedures encompassing all quality checks conducted and their reports as a permanent record of equipments and systems. All QA documents shall be approved by respective QA groups. Fit-up, welding, dimensional checks of installations, leveling, alignment checks, personnel, procedure and equipment qualifications, non-destructive examination etc shall be performed by QA group of manufacturers / work contractors and verified and certified by respective QA groups.

QA for all the stages of manufacture and assembly undertaken at SAS by manufacturers will be undertaken by QA (Procurement) group and site activities by QA (Construction) group.

#### **3. 2.1 Procedures**

All the works and activities shall be executed by the NSSS group as per the duly approved procedures listed below:

- Procedure for erection of support embedment for safety vessel.
- Procedure for erection of support embedment for roof slab.
- Procedure for handling and transportation of assembled equipments (such as main vessel, inner vessel, safety vessel, roof slab and thermal baffles) from SAS to RCB.
- Procedure for site assembly of safety vessel and insulation.
- Procedure for site assembly of main vessel along with core catcher and core support structure.
- Procedure for site assembly of inner vessel.
- Procedure for site assembly of roof slab.
- Procedure for site assembly of thermal baffles.
- Procedures for surface treatment of safety vessel, inner vessel, main vessel and thermal baffles.
- Procedure for optical inspection for critical alignment of various equipments of NSSS.
- Procedure for erection of safety vessel.
- Procedure for erection of main vessel and thermal baffles.
- Procedure for installation of grid plate, pump to grid plate connection pipes.
- Procedure for installation of inner vessel within RCB.
- Procedure for installation of roof slab.

- Procedure for installation of primary sodium pumps.
- Procedure for installation of intermediate heat exchangers.
- Procedure for installation of large rotatable plug and small rotatable plug.
- Procedure for installation of control plug.
- Procedure for erection of transfer arm, IFTM and in-vessel transfer machine.
- Procedure for erection of CSRDM and DSRDM.
- Procedure for installation of fuel and other sub-assemblies in the core.
- Procedure for erection of secondary sodium pumps.
- Procedure for erection of steam generators.
- Procedure for pouring of concrete inside Roof slab, LRP and SRP.

Additional procedures, as required, shall also be duly prepared and approved.

### **3. 2.2 Qualification of Procedures**

Qualification of the processes and the work procedures shall be carried out as specified. Only trained persons shall be deputed for handling critical components / taking measurements of critical dimensions and carrying out certain operations like pre-assembly and installation. Necessary qualification of procedures, tools and operators shall be ensured prior to deployment of the same.

### **3. 2.3 Qualification of Special Tools**

Following special tools shall be qualified prior to deployment on operations or use:

- Temperature measuring devices.
- Various locating tools
- Optical instruments
- Various metrological instruments

On initial qualification, periodic surveillance checks shall be also carried out as declared in various work procedures to ensure maintenance of accuracy of the tools.

### **3. 2.4 Reports**

A list of reports for inspection, manufacturing, welders' qualification, weld inspection, NDE etc. is given below:

- Welding inspection reports
- Support fabrication reports
- Support erection reports
- Radiography inspection reports
- Torquing reports

- Alignment reports
- Functional / Performance test reports
- Installation checklists / assembly reports
- Support erection reports
- Hydro static test / pneumatic test reports
- Surface treatment reports
- Helium leak test reports
- Installation / erection completion certificate

The formats for these reports shall be prepared by QA group of respective manufacturing / works contractors in consultation with NSSS group and shall be approved by respective QA groups. These formats shall be of generic nature. Specific record forms to suit specific activities shall form part of the erection procedures.

### **3.3.0 REQUIREMENTS, RESPONSIBILITIES AND QUALITY ASSURANCE OF PIPING WORKS.**

Major portion of the piping is planned to be fabricated and erected through package contracts. The Piping group shall ensure that all works are executed meeting the specified requirements. QA group of respective manufacturing / works contractors will prepare QA documents such as QA procedures encompassing all quality checks conducted and their records as a permanent record of equipments and systems. All QA documents shall be approved by QA (Construction) group. Fit-up, welding, dimensional checks of installations, leveling, alignment checks, personnel, procedure and equipment qualifications, non-destructive examination etc shall be performed by QA group of manufacturers / work contractors and verified and certified by QA (Construction) group.

#### **3.3.1 Procedures**

All the works and activities shall be executed by the Piping group as per the duly approved procedures listed below:

- Welding and fabrication procedures
- Non-destructive examination procedures
- Leak testing, hydro static and pneumatic testing procedures
- Other work procedures, such as erection procedures, cleaning procedures and surface protection procedures.

Additional procedures, as required, shall also be duly prepared and approved.

### **3. 3.2 Qualification of Procedures**

a) In addition, the following specific qualifications shall also be undertaken:

- Surface treatment (Pickling and passivation)
- Welder performance qualification in special positions

b) Trained personnel shall be deployed for the following specific applications:

- Erection of pumps
- Instrumentation tubing
- Alignment
- Valve testing
- Stress relieving in-situ, wherever required.
- Any other activity identified by BHAVINI at a later date.

### **3. 3.3 Qualification of Special Tools**

Following special tools shall be qualified prior to their deployment on the service and also during the course of their use at the frequency as described in respective work procedures:

- Pipe bending machines
- In-situ stress relieving set-up
- Non-destructive examination equipment
- Bolt torquing devices
- Optical instruments
- Special metrological tools
- Pressure gauges

### **3. 3.4 Reports**

Reports shall be issued for various activities affecting quality. Some of the reports for incoming material inspection, manufacturing, welder's qualification, weld inspection, NDE etc. are listed below:

- Material inspection / acceptance reports with test certificates.
- Welding procedure specifications
- Procedure qualification records
- Welder performance qualifications
- Welding inspection reports
- Pipe support manufacturing reports

- Pipe support erection reports
- Torquing reports
- Bend manufacturing reports
- Line erection reports
- Alignment reports
- Equipment erection reports
- Reports for wrapping / coating
- Stress relief charts
- NDE reports
- Valve test reports
- Equipment / component readiness reports for hydro static test / pneumatic test / Helium Leak Test
- Hydro static test / pneumatic test reports
- Helium leak test reports
- Degreasing / surface treatment reports
- Painting reports
- Construction Completion Certificate
- System transfer document

The formats for these reports shall be prepared by QA group of respective manufacturing / works contractors in consultation with piping group and shall be approved by QA (Construction) group. These formats shall be of generic nature. Specific record forms required for specific works and QA activities shall be prepared and appended to the respective manufacturing, erection and installation procedures.

### **3. 4.0 REQUIREMENTS, RESPONSIBILITIES AND QUALITY ASSURANCE OF BoP-MECHANICAL WORKS (Non-Safety)**

Major portion of manufacturing and erection activities are planned to get executed through package contracts. The BoP-Mechanical group shall ensure that all works are executed meeting the specified requirements. QA group of respective manufacturing / works contractors will prepare QA documents such as QA procedures encompassing all quality checks conducted and their records as a permanent record of equipments and systems. All QA documents shall be approved by respective QA groups. Fit-up, welding, dimensional inspection of installations, leveling, alignment checks, personnel, procedure

and equipment qualifications, non-destructive examination etc shall be performed by QA group of manufacturers / work contractors and verified and certified by respective QA groups.

### **3. 4.1 Procedures**

All the works and activities shall be executed by the BoP-Mechanical group as per the duly approved procedures listed below:

- Welding and manufacturing procedures
- Non-destructive examination procedures
- Leak testing and hydro static testing procedures
- Procedure for installation of major equipments such as turbine generator, condenser and boiler feed pump.
- Other work procedures

Additional procedures, as required, shall also be duly prepared and approved.

### **3. 4.2 Qualification of Procedures**

Following specific qualifications shall be carried out:

- Condenser tube rolling and seal welding.
- Pickling / passivation and painting.
- Stress relieving.
- Welder qualification in special positions.

### **3. 4.3 Qualification of Special Tools**

Following special tools shall be qualified prior to their deployment on service, and also during the course of their use at the frequency as described in the respective work procedures/QA manuals:

- Stress relieving set-up
- Non-destructive examination equipments
- Bolt torquing device
- Optical Instruments
- Specific metrology tools
- Any other equipment / tools identified

### **3.4.4 Reports**

Reports shall be issued for various activities affecting quality. Some of the reports for incoming material inspection, manufacturing, welders' qualification, weld inspection, NDE etc. are listed below:

- Material inspection / acceptance reports with test certificates.
- Welding procedure specifications
- Procedure qualification records
- Welder performance qualifications
- Welding inspection reports
- Pipe support manufacturing reports
- Pipe support erection reports
- Torquing reports
- Bend manufacturing reports
- Line erection reports
- Alignment reports
- Equipment erection reports
- Reports for wrapping / coating
- Stress relief charts
- NDE reports
- Valve test reports
- Equipment / component readiness reports for hydro static test / pneumatic test / Helium Leak Test
- Hydro static test / pneumatic test reports
- Helium leak test reports
- Construction Completion Certificate
- System transfer document
- Degreasing / surface treatment reports
- Painting reports

Formats for these reports shall be prepared by contractors and shall be approved by respective QA groups of BHAVINI. These formats shall be of generic nature. Specific record formats required for specific works and QA activities shall be prepared and appended to the respective manufacturing, erection and installation procedures.

## **CHAPTER – 4**

### **QUALITY ASSURANCE IN ELECTRICAL CONSTRUCTION**

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## **QUALITY ASSURANCE IN ELECTRICAL CONSTRUCTION**

### **4.1.0 INTRODUCTION & SCOPE**

This chapter describes the salient aspects of the quality assurance programme and guidelines on electrical construction activities during construction, installation, inspection and testing & commissioning of related electrical works carried out by electrical construction group and the contractors under their control. All works shall be carried out as per design drawings, specifications, codes and standards. The Quality Assurance Plans will cover the control points for all quality related activities.

#### **GENERAL ASPECTS**

General aspects of Quality Assurance during the project construction phase viz. general requirements, various functions such as management, performance, verification and corrective functions, records and organization charts are covered in Chapter 1 of this manual.

### **4.2.0 GENERAL DESCRIPTION**

#### **4.2.1 Electrical Construction**

Electrical works carried out at site can be classified into the following systems:

- Off – site power system
- Generator and its auxiliaries
- Class IV – normal AC power supply system
- Class III – Emergency AC power supply systems
- Class II – AC Instrumentation and control power supply systems
- Class I – DC Instrumentation and control power supply systems
- Variable speed drives for the sodium pumps
- Electrical preheating system
- Lighting and power sockets
- Cabling
- Grounding systems, lightning protection for buildings and electrical equipment
- Electrical systems that are part of other systems

The off-site power systems for the station services cover the grid connections and the power evacuation scheme and the power supply schemes for various station auxiliary loads required for the startup, power and shutdown operations of the plant.

The plant will be connected to the Tamil Nadu / Southern regional grid to transmit the power generated and these connections also provide off – site power supply to the station. A 220 kV substation with five numbers of transmission lines and double circuit ties to MAPS 220 kV bus are arrived at.

The generator is directly coupled with the turbine and the mechanical input power is converted into electrical power. The electrical power from the terminals of the generator flows to the generator transformer and the two numbers of unit auxiliary transformers through isolated phase bus ducts. The GT steps up the generator voltage of 21 kV to 220 kV, which will be connected to the grid through 220 kV sub-station.

The generator is a three phase, 21 kV, 588 MVA, 0.8 PF (lagging), and 3000-rpm machine. Introduction of GCB is a special feature of the power system.

Class IV power supply system derives its power from different sources of supply as mentioned below.

- From the grid through a 220 kV / 6.9 kV station transformer
- From the grid through a 220 kV /21 kV generator transformer and 2 numbers of 21 / 6.9 kV unit auxiliary transformer (UAT) with the generator breaker kept in open position.
- From the terminals of the TG through the two numbers of 21 / 6.9 kV UAT when the generator circuit breaker is closed during power generation.

The class III 6.6 kV buses are normally supplied from the unit buses with the bus coupler of class III 6.6 kV buses closed and the feeders from the station bus act as standby.

Standby emergency Diesel generators are provided as on site sources of AC power to feed the class III supply system only for supplying the loads which cannot tolerate interruption of supply for more than a few minutes following the loss of the class IV normal supply from the grid. There are 4 DG sets of 3 MVA capacity each connected to one section of class III power supply bus at 6.6 kV level.

Class II 240 V, AC, single phase, 50 Hz UPS supply is provided for computers, distributed digital control equipments and other hardware requiring no break of supply. Reactor safety and safety related control system equipment would also be fed from this supply.

Class I 48 V DC and 220 V DC power supplies are connected to Instrumentation and Control loads in the PFBR.

Variable speed AC drives are provided for the two primary and two secondary sodium pumps. The supply to these drives systems for normal operation is fed from the class III bus.

The sodium circuits are provided with electrical pre-heating arrangement. The following circuits provided with electrical pre-heating are supplied from the class III buses.

- Safety grade decay heat removal system pipeline and equipment
- Primary sodium purification systems dump lines.
- Hydrogen leak detection system pipelines and equipment
- Fast dump lines in the secondary sodium system

The cables are divided into three basic groups:

- Power cables
- Control cables
- Instrumentation cables

The power cables are further grouped based on the operating voltage of the system and they are EHV cable for 220 kV, HV cable for 6.6 kV and MV cable 415V and below. All the cables are FRLS cables. Single core cables are to be laid in trefoil formation.

#### **4.2.2. Manufacturing of Electrical Equipment / Systems**

- Prior to commencement of manufacturing activities, detailed manufacturing process sheets, assembly procedures and Quality Assurance Plans shall be prepared based on applicable approved drawings, specifications and codes and shall be approved by the Purchaser. The QAPs detail different stages envisaged in the manufacture of the equipment, viz., material inspection, procedures and personnel qualifications, consumables, layout and cutting plan, non-destructive examination, electrical and mechanical tests and painting etc as per the

specification requirements. The QAPs also specify review, witness and hold points assigning responsibilities to manufacturer, supplier, works contractor or their authorized representatives, QA groups of BHAVINI, concerned project execution groups at site. Detailed procedures, checklists and technique sheets shall be formulated, reviewed and approved for all relevant activities such as manufacturing, electrical and mechanical tests, non destructive examination, painting etc.

- On approval of QAP and manufacturing documents, the equipment shall be taken up for manufacturing. Manufacture and stage inspections shall proceed as per the approved QAP and manufacturing documents. In the event of any deviations desired by manufacturers / purchaser, QAP and manufacturing documents shall be revised accordingly and approved prior to implementing them.
- In the first stage, raw material inspection shall be undertaken. Test certificates shall be correlated and wherever linkability is not established, necessary tests as required by the relevant specification shall be carried out. Welding procedures, brazing procedures, welders and brazers shall be qualified.
- Wherever welding / brazing is involved, stage NDE activities shall be carried out. Any discontinuity revealed during non-destructive examination shall be evaluated and the discontinuities beyond acceptable limit shall be repaired. All the NDE specified for original requirements shall be repeated for the repaired area after repair to ensure that the discontinuities are within acceptable limits.
- Well-trained and qualified personnel shall carry out NDE and other relevant inspection activities. Records of qualified and certified inspection personnel shall be maintained by manufacturers and shall be produced when required by the purchaser for necessary verification.
- On completion of manufacture, the components shall be assembled into sub-assemblies and final assembly and also inspected in accordance with the approved assembly procedures.
- Electrical and mechanical tests shall be carried out as per the relevant specifications / procedures.
- As built drawings, manufacturing procedures and records of quality surveillance including material test certificates, dimensional inspections, reports of all destructive and non destructive examinations, weld inspection and test reports shall be documented with proper serial number and date for each system.

#### **4.3.0 ELECTRICAL CONSTRUCTION ACTIVITIES UNDERTAKEN BY ELECTRICAL CONSTRUCTION GROUP**

Careful and detailed planning, execution and documentation shall be undertaken to assure that specified quality shall be imparted to the works executed by electrical construction group. Broadly these activities involve following:

- Pre-installation verification
- In-process verification
- Post-installation verification
- Preservation of installed systems.

#### **4.3.1 Testing Facility at Site**

Before taking up any electrical construction activity at site, a testing laboratory with the following facilities will be established by the contractors/BHAVINI for carrying out the calibration / testing of electrical equipment at project site:

- Visicorder
- HV Megger
- Relay test kit
- Moisture content analyzer
- Transformer ratio meter
- BDV test kit
- Micro ohmmeter
- DC high pot test set
- CB timer
- Power quality analyzer
- Humidity & temperature meter
- Dielectric strength meter
- Winding resistance test set
- Digital Thermometer
- DC earth fault locator
- Sound level meter
- Multi function calibrator
- CT test set
- Digital Lux meter

- Loop calibrator
- Oscilloscope cum recorder
- Power supply unit
- Battery management system
- Static excitation test set
- Primary injection test set
- C&DF test set
- Energy meter calibrator
- Thermal O/L test set
- Motor analyzer
- Multi meter.

The instruments to be deployed in the main plant works and other places shall be tested / calibrated periodically prior to their use periodically. All testing and calibration works shall be undertaken complying the relevant approved procedures. Number of each of the above test kits shall be sufficient enough to take up multiple activities at a time.

#### **4. 3.2 Pre-Installation Verification**

Equipment / materials received from vendors' shops and manufactured at plant site shall be required to be installed at plant site. All electrical manufacturing activities at site generally involve following stages:

##### **4.3.2.1 Checks carried out prior to Installation of Electrical Equipment / Systems at Site**

Prior to taking up installation work, following checks shall be undertaken to ensure correctness of supply of equipments and components.

- Shipping release and material test certificates/ Performance test certificates shall be available for the items purchased from the market.
- Material and equipment and their storage are checked to ensure their conformance with the latest applicable approved drawings, equipment lists / Bills of Material and specifications and manufacturer's recommendations.
- It shall be ensured that loading at works, transportation and unloading at site, safe storage, checks during storage and the preservation measures have been maintained during storage.

- Equipments manufactured and assembled at manufacturers shop and supplied, shall have all the documents, viz., approved installation procedures, QAPs, latest drawings, instruction manuals and any special work instructions required for specific equipment, material test certificates, performance test reports, shipping release etc. The documents shall be available at site.
- Duly qualified and documented procedures for installation / processes and other applicable documents shall be available. In the installation procedure, responsibilities of housekeeping of the installation areas shall be clearly defined.
- Identity of the items shall be duly established with respect to approved construction documents, viz., drawings, equipment lists, specifications etc.
- It shall be ensured that all manufacturing and assembly work on the item inclusive of any site work as indicated in history docket / shipping release has been completed and the item cleared for installation.
- It shall be ensured that the installation area is ready for installation of the equipment. The hindrances and obstacles interfering with other equipments shall be duly reviewed and eliminated. It shall be ensured that interference due to particular equipment or activity does not affect other equipment installation work. Installation sequence of various equipments, particularly where space is likely to be a constraint shall be worked out in advance.
- It shall be ensured that the material and equipments are free from physical damage, distortion, corrosion, contact contamination and condensation and they are cleaned in accordance with the specifications. Care shall be taken to ensure that the cleaning solutions and other items used shall not be detrimental to the electrical equipment / component.
- All personnel employed in installation, erection, inspection and testing works shall be qualified and certified by BHAVINI Construction Directorate as required. All personnel employed in installation, inspection and testing of electrical / instrumentation work shall be qualified and have valid licenses as per Indian Electricity Rule (wherever applicable). The technicians shall be given special training for the installation of special equipments / jobs, such as installation of Reactor Building cable penetration sealing and duly qualified in the said works. Wherever necessary, mockup shall be carried out.
- It shall be ensured that all the erection tools, material handling equipment (Cranes, Trucks, tools etc) and calibrated instruments are duly qualified and

available for use. All instruments and gauges used for installation, inspection and testing shall be duly calibrated.

- Testing instruments and gauges and all material handling / lifting equipments used for checking the installation, inspection and testing of equipments shall be calibrated to the acceptance standards and their records maintained.
- The mounted relays, control devices and instruments shall be checked and calibrated as per approved procedures, and their data history cards shall be maintained.
- Installation area shall meet the specified requirements, viz.,  
Cleanliness including provision of temperature and humidity control, wherever applicable
  - Protection from adjacent construction activities, as required
  - Protection from inclement weather and other adverse ambient conditions
  - Provision for permanent and temporary supports and
  - All precautions for the safety of personnel, equipment being installed or nearby area or equipment.
- Non-conformance, if any, shall be resolved and documented.

#### **4. 3.3 In-Process Verification**

Inspection of work areas in progress shall be performed to verify that equipment / systems are transported, located, erected, installed, assembled and connected in accordance with the specified procedures and the equipment already positioned in the area are not affected by the planned works of others. The inspection includes verification of following:

##### **4.3.3.1 Verification of Work Area**

- Cleanliness / housekeeping of work area (Existence of barriers and protective covers and effective housekeeping) to ensure that equipment and components will not be damaged or contaminated as a result of personnel traffic, weather or adjacent construction activities such as concreting, chipping, jack hammering, welding / brazing and acid cleaning. Keeping the above aspects as guidelines, detailed step by step installation procedure shall be drafted for each system/ equipment. Stage inspection and documentation aspects are also to be included.

- Clearances and dimensional tolerances available for handling and installation of materials, equipments / systems.
- Completeness of pre-requisite activities.
- Clearance from industrial safety group is obtained for activity. In case of work on energized systems, it is to be ensured that system is de- energized, discharged and earthing contacts is continuously maintained.

#### **4.3.3.2 Verification of Equipment / System during Installation**

During installation of electrical equipments / systems, following aspects shall be verified:

- Physical integrity of equipment including tightness of connection and fasteners, fluid level and pressure, leak tightness, condition of protective coating, protective covers on threaded and machined surfaces.
- Leveling, alignment and orientation of components and supports to be connected shall conform to drawing/ specification requirements.
- Freedom of moving parts shall be ensured.
- Necessary supports, hangers, restrainers, dampers and shock absorbers shall be installed.
- Limit switches, interlocks, stops, if applicable shall be provided.
- Greasing and lubrication points and access to these points.
- Electrical circuit controls, relays.
- Connections as per approved drawings
- In case of assembly of equipment at site, erection key diagrams and erection procedures as per the accepted manual shall be followed.

The above aspects shall be verified during installation of the following electrical equipment / systems:

- 220 kV Switch yard
- 220 kV System Protection & Control
- 220 kV Lighting Arrestor
- 220 kV CVT
- Mechanical Services for Switchgear
- Generator Circuit Breakers
- Generator Transformers
- Unit auxiliary Transformers

- 21 kV Isolated Phase Bus Ducts
- Start Up Transformers
- 50 MVA Service Transformer
- Metering and Billing System
- Synchronizer
- 6.6 kV Auto Transfer Scheme
- 6.6 kV Switch gears
- D.G. sets & fuel oil System
- 6.6 k.V. / 415 V Auxiliary Transformers
- 415 V Switch gears
- Bus ducts
- Motor control centers
- Power UPS & soft starters
- Power Battery banks
- 400 V DC Switch gears
- 6.6 k.V and 415 volt EMTR
- Control Battery Banks
- Battery Chargers, ACVR, Load Bank
- 220 V D.C. Distribution Boards
- Electrical SCADA & disturbance Recorder
- Cable trays & Accessories
- EHV Cable
- HT power cables
- LT power cables
- Control cable
- Cable terminations
- Lighting Fixtures
- Receptacle
- Structural Steel
- GI Conduit
- Wire
- Cathode Protection
- Elevator
- Fire Barriers / Break
- Cable Sealing / Penetration in RCB

- Grounding
- Fire protection system
- Electrical control and protection panels
- Lightning protection

#### **4.3.3.3 Monitoring / Verification of Activities during and after installation**

Monitoring / verification of activities during and after installation include the following:

- Latest approved documents shall be followed.
- Approved procedures, duly inspected and qualified materials, tools and calibrated measuring instruments shall be used.
- Approved installation, inspection and testing procedures shall be available.
- Duly qualified personnel, and / or having valid licenses (wherever applicable) are deployed on the job.
- "As-built" information shall be recorded.
- The status of installation shall be clearly indicated in the appropriate records.
- Non-conforming materials shall be controlled.
- Location and orientation of components shall be checked.
- Leveling and alignment shall be checked.
- Installation, identification, numbering and tagging of cables/ cable trays shall be carried out.
- Condition of protective coating / Fire barriers / Fire stops shall be checked.
- Grounding & shielding shall be properly checked and recorded.
- Terminations shall be effected.
- Physical integrity shall be verified.
- Identification marks shall be effected.
- Freedom of moving parts shall be ensured.
- Accessibility for inspection, maintenance of the equipment, controls, purging and removal of purging arrangements on completion of job.
- Access for cooling air.
- Cleanliness of systems, inside and outside.

#### **4.3.3.4 Calibration of Instruments**

Site testing and calibration of all instruments shall be carried out during installation and every year. The standard instruments used for calibration / testing shall have accuracy better than or at least equal to the instrument under test and shall have requisite traceability to Primary Calibration Standard. The calibration procedures shall be prepared stating calibration requirements and the frequency of all measuring and test instruments, equipment / tools.

The calibration procedures shall be based on the applicable relevant recognized standards and recommendation of suppliers of equipment. The instruments found not meeting the calibration accuracies or damaged shall not be used. After repair, the instruments shall be recalibrated. A record of calibration shall be maintained. Non-confirming instruments / equipment shall be disposed off as per the approved procedures. Only trained, skilled, qualified and experienced persons shall be authorized to under-take calibration work. Proper records shall be maintained in the approved format. The instruments used for calibration / verification shall not be used for field work.

Following special tools shall be qualified prior to their deployment on service, and also during the course of their use at the frequency as described in the respective work procedures / QA Manuals:

- Calibration instruments
- Non-destructive examination equipments
- Equipment specially used for electrical installation
- Any other tools identified

#### **4. 3.4 Qualification of Equipment, Procedures and Personnel**

##### **4. 3.4.1 Qualification of Equipment / Consumables**

The equipment / consumables, as listed below shall be qualified prior to being put to use. Consumables from reputed manufacturers with test certificates need only be used. Identification and traceability of product batch to the test certificate to be ensured.

- Critical tools and measurement tools
- Welding / brazing equipments

- Welding / brazing consumables
- NDE consumables
- Electrical items and consumables

Qualification of consumables and equipment shall be undertaken in accordance with the relevant procedures assuring that all the measuring and test equipment have the range, type, condition and accuracy to achieve and maintain conformance with the specific requirements. All such equipment shall be adjusted, maintained and calibrated following specific procedures. Records of adjustment, maintenance and calibration with their validity shall be maintained, and equipment suitably identified and marked.

#### **4.3.4.2 Training and Qualification of Personnel**

**Refer Para 1.3.4.**

#### **4.3.5 Procedures for Electrical Construction**

All execution works and activities shall be performed by adhering to the duly approved procedures, quality plans and checklists etc. All documents shall be duly filled up with execution data, authenticated and maintained. Prior to commencement of execution of activities, the following applicable procedures along with relevant drawings shall be formulated, established, qualified and approved:

- Manufacturing procedures.
- Erection / installation procedures for electrical equipment.
- Electrical and mechanical testing procedures.
- Calibration procedures for all instruments.
- Inspection procedures.
- Procedures for training and qualification of personnel.
- Welding / brazing procedures.
- NDE procedures.
- Cleaning procedure.
- Preservation / Protection steps.

Above list is only indicative and of generic nature. Additional procedures as required shall also be formulated, approved and implemented.

### **4.3.6 Post-Installation Inspection and Verification**

Inspection of installed systems shall be performed to ensure compliance with the specified requirements. Installed equipment and systems shall be tested to demonstrate that the installed equipment and systems perform in accordance with design and performance requirements. Each installed system shall be tested starting with equipment in isolation, with sub-systems and finally the complete integrated system in accordance with the specification / approved procedures.

Inspection shall be performed on installed electrical equipment and systems to verify the following:

- The installation has been done as per latest drawings and specifications.
- Equipment and materials have not undergone any damage during installation.
- Location, leveling and alignment, of installed equipment are as per approved procedures.
- Interspacing and routing of cables, cable trays etc. meets the specified requirements.
- Grounding, terminations, shielding, and identification tags meets the specified requirements.
- All non-conformances have been resolved satisfactorily.
- Appropriate protective measures have been taken after installation.

The equipment / material / items not conforming to the stipulated requirements shall be recorded equipment wise/ system wise, reviewed and disposed as given in 1.6 of this manual.

The requirement to be followed during inspection of installed systems is given below in brief:

#### **4.3.6.1 Cleaning of Systems**

- Inspection shall be performed to verify that installed systems and components are cleaned and conditioned as per approved procedures.
- The cleaned systems shall be preserved as per approved procedures.

#### **4.3.6.2 Post Installation Electrical Tests**

Electrical tests shall be carried out as per approved procedures meeting relevant specifications and test data recorded on installation of the equipment. The electrical tests for various equipments shall be carried out based on commissioning procedure applicable for respective equipments / systems which shall be finalized in consultation with O & M / commissioning group. Acceptance shall be based on technical specifications / BIS standards / manufacturers' recommendations. Before commencement of testing and before actual energisation the following aspects shall be ensured.

- Healthy condition of all components of the system.
- Cleanliness – general areas, current carrying parts etc
- Tightness of current paths – power & control
- Vermin proofness – inter-compartments of a panel, inter-panels of the switch board and switch board to outside environment.

#### **4.3.6.3 Post Installation Mechanical Tests**

Mechanical tests as required shall be performed to ensure that electrical components or systems can withstand rated pressures. This is applicable for Reactor Building (RB) cable penetration sealing assembly. The tests shall conform to the requirements specified in the applicable codes, standards and procedures and shall be conducted after the assembly is completed.

Following tests shall be conducted on various welding jobs (bus ducts), if any, as per requirement indicated in technical specifications.

- Surface preparation
- Edge preparation and fit up
- Root pass inspection / NDE
- Final pass inspection / NDE

#### **4.3.7 Pre-Service Inspection**

Pre-service inspection shall be performed to collect the base line data on the electrical equipments / systems. Actual equipment / systems to be inspected and the extent / type of base line data collection shall be detailed in ISI / PSI Manual for PFBR. Such data

collected shall consist of all indications observed, clearly mentioning the location with respect to a known reference structural member / equipment.

The data shall be generated in line with in-service inspection programme issued by Technical Directorate / REG, IGCAR. These data shall be compiled and report issued as permanent records. Corrective actions, as required, shall be undertaken by site.

#### **4. 3.8 Analysis and Evaluation of Inspection and Test Results**

Procedures shall be established for processing inspection and test results and for their analysis and evaluation. These procedures shall include the referencing of codes, standards, specifications or other special requirements and their limiting values. The data processing procedures shall provide for preliminary evaluation to determine validity of the results and the appropriateness of continuing the inspection or test.

The test results shall be analyzed and evaluated to verify the completeness of the results, inspection and test objectives, conformance with the acceptance criteria limit for each activity being completed for equipment and systems. Reports shall be prepared for every inspection and testing activity covering the test results, their analysis and evaluation.

#### **4.4.0. QUALITY ASSURANCE REQUIREMENTS AND RESPONSIBILITIES FOR ELECTRICAL CONSTRUCTION ACTIVITIES**

It is planned to get executed the major portion of manufacturing and erection of electrical construction activities through package contracts. The electrical construction group shall ensure that all the works are executed meeting the specified requirements. QA group of respective manufacturing / works contractors prepare QA plans and other QA documents such as QA procedures encompassing all quality checks conducted and their reports as a permanent record of electrical equipments and systems. All QA documents shall be approved by the respective QA groups. Electrical tests, mechanical tests, personnel, procedure and equipment qualifications and inspection on welding / brazing such as non-destructive examination shall be performed by QA group of manufacturers / work contractors and verified and certified by respective QA groups.

#### **4. 4.1 QA Procedures**

All the works and activities shall be executed by the electrical construction group as per the duly approved procedures listed below:

- Manufacturing procedures
- QA plans
- Electrical and mechanical testing procedures
- Procedure for installation of electrical equipments
- Non-destructive examination procedures
- Other inspection / testing procedures

Additional procedures, as required, shall also be duly identified, prepared and approved. Acceptance criteria for each equipment and sub-system shall be prepared and approved.

#### **4. 4.2 Reports**

Reports shall be issued for various activities affecting quality. Some of the reports for incoming material inspection, manufacturing, welders' / brazers' qualification, weld inspection, NDE etc. are listed below:

- Material inspection / acceptance reports with test certificates.
- Equipment erection reports
- Equipment / component readiness reports for electrical and mechanical tests
- Electrical and mechanical test reports
- Electrical Termination procedure qualification reports
- Welding / brazing procedure specifications
- Procedure qualification records
- Welder / brazer performance qualifications
- Welding / brazing inspection reports
- NDE reports
- Painting reports
- Construction Completion Certificate
- System transfer document

Formats for these reports shall be prepared by contractors in consultation with electrical construction group and shall be approved by BHAVINI. These formats shall be of generic nature. Specific record formats required for specific works and QA activities shall be prepared and appended to the respective manufacturing, erection and installation procedures.

#### **4.5.0 PRESERVATION OF INSTALLED ELECTRICAL EQUIPMENT AND SYSTEMS**

- All electrical equipment and systems installed and fully tested but not put into operation due to non-availability of connected systems or equipment shall be preserved with proper protection.
- All such installed electrical equipment shall be duly preserved, protected and maintained as per applicable procedures duly formulated and approved, for ensuring their efficient availability as required during system commissioning stages.
- The preservation procedures for various equipment and systems shall be formulated, approved and maintained by the concerned groups.
- Preventive steps towards likely damage of any equipment during transportation and installation of nearby equipment to be ensured.

## **CHAPTER – 5**

### **QUALITY ASSURANCE IN INSTRUMENTATION CONSTRUCTION**

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## **QUALITY ASSURANCE IN INSTRUMENTATION WORKS**

### **5.1 INTRODUCTION & SCOPE :**

This chapter describes the salient aspects of the quality assurance programme and guidelines on Instrumentation activities during construction, installation, inspection and testing & commissioning of related instrumentation works carried out by Instrumentation group and the contractors under their control. All works shall be carried out as per design drawings, specifications, codes and standards. The Quality Assurance Plans will cover the control points for all quality related activities.

To achieve the specified quality in the instrumentation works, following aspects are ensured.

- 1) Selection of approved hardware and consumables to specified requirements.
- 2) Use of approved construction procedures / QA Plans.
- 3) Deployment of Qualified personnel.
- 4) Evaluation of performance of various tests on the process hookup lines to check the system integrity and its conformance with the specified requirements.

### **GENERAL ASPECTS**

General aspects of Quality Assurance during the project construction phase viz. general requirements, various functions like management, performance, verification and corrective functions, records and organization charts are covered in Chapter 1 of this manual.

### **5.2 SELECTION OF INSTRUMENTS AND HARDWARE :**

All major items of Instrumentation systems are categorized into suitable sub-packages by Technical Directorate for the procurement purposes as indicated below:

- i. Sub Packages for common I & C System in Nuclear Island, CR & ECR, interfacing with Power Island.
- ii. Sub Packages under field instrumentation for Power Island including electrical power system.
- iii. Sub Packages being procured under different tenders for auxiliary package.
- iv. Instrumentation associated activities in other packages.

Responsibility for engineering and finalization of specification of all the I & C systems lies with REG, IGCAR. IGCAR may appoint consultants for the design and finalization of specification. Procurement and Supply part of packages is controlled by Technical Directorate.

### **5. 2.1 SUB PACKAGES UNDER FIELD INSTRUMENTATION PACKAGE :**

For each item under field instrumentation Package, a detailed specification, Brand / Model, indicative QAP are provided in the tender document. Package Contractor shall short list the vendors and submit the same for approval to Technical Directorate. Before manufacturing of items the qualified vendor shall submit QA Plan for approval to Technical Directorate.

### **5. 2.2 Q.A IN MANUFACTURING:**

The Evaluated and Pre Qualified short listed material, equipment manufacturers are selected based on their product quality and the product performance in other Nuclear Power projects. To ensure quality in manufacturing, approved QAPs are to be strictly followed. BHAVINI QA or their authorized representatives are entrusted with QS of stage wise manufacturing process as per QAP. The specified tests are conducted, witnessed as per approved Inspection Procedure by BHAVINI QA and test reports are issued. Materials thus accepted are cleared for shipping by BHAVINI QA or their authorized representative.

### **5. 3 SELECTION OF COMMON HARDWARES AND CONSUMABLES :**

The common hardware and consumables ( Viz. GI Light channels, GI Conduits, Cable Glands, Tube Clamps, Anchor fasteners, Sleeves etc. ) shall be procured by the Instrumentation Package Contractor on Site control. For all common consumables and hardware items required for instrumentation work a short listed source of qualified products is suggested and indicative QAPs are provided to the Contractor. Prior to procurement of the items, the Contractor shall submit their approved vendor list and actual QA plan for approval at site. Procurement of the items shall be undertaken by the Contractor on the basis of approved Vendor list and QAPs and duly inspected by BHAVINI QA or their authorized representative.

#### **5.4 MATERIAL RECEIPT & STORAGE:**

The instrumentation package contractor is responsible for material receipt, its inspection and storage. The contractor shall construct closed, dust and rain free ware houses, a dust free storage room for storage of specified items in controlled atmosphere as required. On receipt of material at site, inspection shall be carried out. Receipt, acceptance and storage of the items shall be undertaken in accordance with approved Procedures.

#### **5.5 CALIBRATION OF INSTRUMENTS:**

An instrumentation calibration laboratory for calibration of the items, equipment shall be set up at the project plant site either by BHAVINI or by a contractor. The laboratory shall have controlled dust free environment and duly qualified Personnel to perform the works. Alternatively, the IGCAR lab facility may also be utilized.

The following checks shall be performed in general,

- 1) The model no., specification and Tag no. of instrument with instrument specification sheet.
- 2) Calibrate the instrument as per approved procedure for accuracy and hysteresis.
- 3) Confirm instrument for proper functioning .
- 4) Check IR value.
- 5) Any other checks and Tests as required at Site.

#### **5.6 PREPARATION OF PROCEDURES :**

Instrumentation Erection and Calibration procedures are prepared incorporating manufacturers instructions. Qualified and Approved procedures shall then be followed for instrument installation work. List of such procedures are given below. Additional Procedures as required shall be formulated and duly approved and implemented in undertaking applicable testing and calibration work.

##### **5.6.1 LIST OF INSTRUMENTS ERECTION PROCEDURES :**

- General instructions for cleaning of instrumentation items and various tests.
- Procedure for installation of instruments.
- Procedure for installation of panels, JB's, ISS and Air accumulator tanks.
- Procedure for installation of Light Channels.
- Procedure for preparation and laying of SS tubes.

- Procedure for Auto tube welding.
- Procedure for preparation and laying of SS double compression tube fittings.
- Procedure for preparation and laying of Copper tube.
- Procedure for preparation and laying of brass fittings.
- Procedure for Copper tube brazing.
- Procedure for preparation and laying of Cable and glanding.
- Procedure for fabrication, fillet welding and Liquid Penetrant Examination.
- Procedure for screwed terminations.
- Procedure for soldered connection.
- Procedure for surface preparation and painting.
- Procedure for Grounding & Shielding practices.
- Procedure for establishing record room for drawings and Documents.
- Procedure for preparation and laying establishing stores and material management.
- Procedure for Preservation of installed items.
- Procedure for Installation of Hilti / Anchor Bolt.
- Procedure for installation of cable trays and tube trays.
- Procedure for Thermo couple junction making.
- Procedure for MI cable termination.
- Procedure for thermocouple installation.
- Procedure for leak detector installation.
- Procedure for installation of special sodium instrumentation.

#### **5. 6.2 LIST OF INSPECTION AND CALIBRATION PROCEDURES :**

- Procedure for establishing instrumentation testing & calibration laboratory.
- Procedure for calibration of controllers.
- Procedure for Testing of Solenoid valves.
- Procedure for calibration of Pressure gauges.
- Procedure for calibration of Pressure switches & Differential Pressure switches.
- Procedure for calibration of Recorders.
- Procedure for calibration of Transmitters.
- Procedure for calibration of Hand Controllers.
- Procedure for calibration of I/P Converters.
- Procedure for calibration of Dial Gauges and data logger.

- Procedure for calibration of analytical instruments.
- Procedure for calibration of temperature and flow instruments.
- Procedure for calibration and stroking of control valves.

## **5.7 TRAINING & QUALIFICATION OF PERSONNEL:**

**Refer Para 1.3.4**

## **5.8 INSPECTION AND QUALITY CONTROL OF INSTRUMENTATION INSTALLATION WORK :**

The construction Contractor shall have independent quality control, inspection and testing Organisation. Quality control, inspection, testing and commissioning of installed work are under the scope the main contractor. BHAVINI QA shall verify and audit the Contractor work at important critical hold points duly identified in the QAP, list of such QAPs are as below. Non conforming material, equipment and works shall not be inducted into the plant works.

- 1) QAP for Receipt inspection and calibration of instrument items.
- 2) QAP for Fabrication and Welding.
- 3) QAP for Installation of panels, JB's ISS, other support.
- 4) QAP for installation of Instruments.
- 5) QAP for SS tube laying, swaging
- 6) QAP for SS tube butt welding by Auto tube welding machine.
- 7) QAP for copper tube laying, installation of brass fittings & brazing.
- 8) QAP for Cable laying, glanding and wire terminations.
- 9) QAP for Air leak search, hydro static test and helium leak test.

## **5.9 SYSTEM TESTING :**

Testing of the completed systems are carried out following duly approved test schemes.

- All the tests are witnessed and certified by Contractor QA, Erection Group and BHAVINI QA.
- After successful test the prescribed format, is filled and signed with name and date by all the groups.

## **5. 10 RECORDS:**

Following records shall be preserved and handed over to O&M along with Construction Completion Certificate (CCCs) /System transfer Document (STD)

- (1) Procurement orders, shipping release, Test reports & Calibration reports.
- (2) History Dockets.
- (3) Inspection reports of erection activities.
- (4) Instrument testing and calibration reports.
- (5) DCRs.
- (6) Test Reports of pneumatic / Helium / Hydro tests and commissioning reports.
- (7) CCCs / STDs.
- (8) As built information.

Other additional documents / records as required in the course of execution of works may also be preserved.

## **CHAPTER – 6**

### **Quality Assurance during Commissioning of Equipment and System.**

(Note: A separate QA Manual on Commissioning will be issued when the commissioning group is set up.)

- 6.1 This section gives only bare minimum guide lines about commissioning.
- 6.2 The commissioning shall be done as per approved procedure and requirements.
- 6.3 Prior to placing the equipment and systems into operation, commissioning shall be performed to demonstrate that the design intent, functional adequacy of components, system and structures, and to eliminate deficiencies observed during testing.
- 6.4 Commissioning activities shall be started only after completion of respective construction activities supported by construction completion certificate / system transfer documents.
- 6.5 All the commissioning activities shall be planned in advance.
- 6.6 All the commissioning activities shall be performed as per approved procedures and QA Plans.
- 6.7 Any modification, replacement and repair activities during commissioning shall be planned, controlled and performed as per approved procedures, instructions, drawings and checklists.
- 6.8 Procedures shall be established and implemented to maintain the required degree of cleanliness during commissioning activities.
- 6.9 All field changes and non conformances shall be controlled and documented as per approved procedures.