

# Quality Assurance during Site Construction of Nuclear Power Plant

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**Abstract**— To achieve the required level of safety and design standards quality assurance is necessary in all aspects of nuclear power plant including site construction. Quality Assurance programmes needed will vary, depending on the site construction activity being performed. The effect on safety of an error in service or the malfunction or failure of an item is the most important factor to be considered in determining the extent of quality assurance efforts. The Responsible Organisation (RO) i.e. the organization having overall responsibility for the nuclear power plant, is responsible for establishing and implementing the quality assurance programme during site construction. Such RO will delegate all or part of this work of establishing or implementing the quality assurance programme to other organisation. But at the same time RO retain the responsibility of effectiveness of entire programme.

**Keywords**— *Quality Assurance; Responsible Organisation; Construction.*

## I. INTRODUCTION

To match the specifications as per standards and gain required level of safety quality control system is implemented in all phases and activities of nuclear power plant covering design, procurement, manufacturing, construction, commissioning, operations and decommissioning. In view of quality control during construction, the following aspects should be considered:

- i. The nuclear power plant construction extends over a large time span, often four to five years or even more. Work is carried out in two or three shifts. The quality control effort has to extend throughout the life span of the project;
- ii. Work is spread over vast areas of the plant; quality control and assurance are needed in every area;
- iii. Several types of activities are undertaken simultaneously in the construction project. Quality issues and control measures could be different for various activities;
- iv. The construction site conditions are normally more difficult to check compared to the conditions in a lab or manufacturing shop floor. Work and inspection are to be carried out simultaneously under often hazardous conditions in construction sites.

- v. Work is carried out by large numbers of people, most of which are not permanent staff of the utility and hence less concerned with quality which must be ensured even for migratory workers who stay at the site for a limited duration.

So while implementing quality control during construction of nuclear power plant all above aspects must be considered. But if quality control is one side of coin then quality assurance is the other one. Hence in addition to Quality Control (QC), Quality Assurance (QA) is also implemented in each construction activity of NPP. The important reason behind it is, quality assurance provides adequate confidence that an item or facility will perform satisfactorily in service as per design specification.

Quality Assurance during site construction of nuclear power plant is implemented for management function, performance function and assessment of construction activities. All these aspects are discussed hereunder.

## II. QUALITY ASSURANCE FOR MANAGEMENT FUNCTION DURING CONSTRUCTION

### A. *Quality Assurance Programme (QAP)*

The quality assurance (QA) programme is an interdisciplinary management tool that provides a means for ensuring that all work is adequately planned, correctly performed and assessed. It provides a systematic approach for accomplishing work with the ultimate goal of doing the job right the first time. The responsible organization (RO) shall develop and implement a QA programme which describes the overall arrangements for the management, performance and assessment of the nuclear power plant during construction. The QA manual which outlines the basis of the QAP should be submitted to the regulatory authorities for review and any check or hold points required by regulatory authorities should become part of the QA plans.

The responsible organization may delegate and/or require suppliers or other organizational units to develop and implement all or part of the QA programme, but should retain overall responsibility for the implementation and effectiveness of the programme. In such cases, the supplier(s) or other organizational units should prepare QA programmes for the work for which they will be responsible and submit them to the responsible organization, if required.

To establish a QA programme, an organization should:

- i. Identify the activities that have to be carried out.
- ii. Review the applicable regulations and standards and the organization's management and technical practices to determine whether the work activities are adequately addressed.
- iii. Review the Code, the QA Safety Guides and other relevant NUSS Codes and Guides to identify shortcomings and assign priorities to those areas requiring improvement or development.
- iv. Establish time-scales within which the required changes should be implemented.

#### B. Grading

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

Special aspects in construction phase that could be graded are:

- i. Qualification of special construction process or personnel to carry them out;
- ii. Extent and details of procedures and degree of their review;
- iii. Degree in process controls, hold points and sample points;
- iv. Requirements of material traceability; and
- v. Pre-service inspection.

#### C. Organisation

RO should appoint a construction organisation to manage, coordinate and supervise NPP construction. Construction organisation is responsible for ensuring that:

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

#### D. Interfaces

Interface arrangement should be agreed with construction organisation, contractors and other organizational units performing the work. They should be defined in writing and may be included in the contract documentation.

Interfaces that should be addressed include:

- i. Contractor and construction organisation;
- ii. Contractor and test and commissioning personnel or organisation;
- iii. Interfaces with sub contractors;
- iv. Interfaces with design authority, corporate QA, health and safety, etc;
- v. Interfaces with siting organisation; and
- vi. Construction organisation and regulatory body.

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

#### E. Training and Qualification

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

#### F. Non-Conformance Control and Corrective Actions

Non-conformances that are required to be reported and recorded should be identified by the construction organisation. Before taking any remedial action the cause of defective work and proposed corrective action to prevent re-occurrence should be agreed with the construction organisation. Following figure 1 shows how non-conformances are reviewed by QA and clearance to next stage is given.

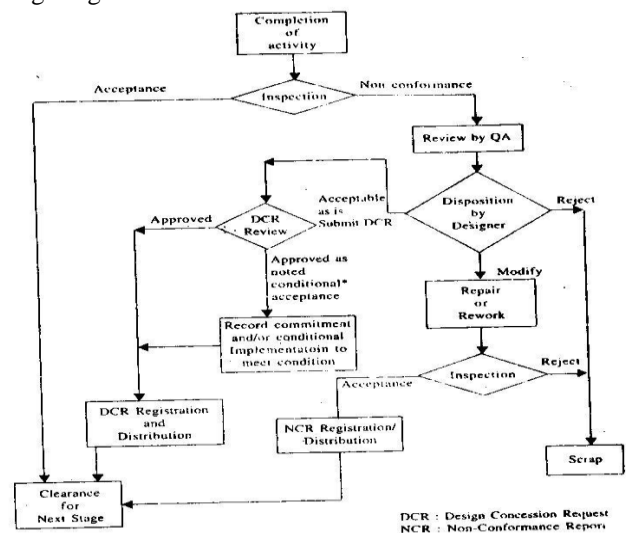


Figure 1: Non-Conformance Control and Corrective Actions

### G. Document and Record Control

Construction organisation shall establish a system for controlling documents containing information necessary to ensure that the construction of NPP fulfills specified requirements. A record system should be established which includes arrangements and responsibilities for categorisation, receipt, review, indexing, storage, retrieval and disposition of construction records

### H. Internal Review Committee for QA and Safety

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

## III. QUALITY ASSURANCE FOR PERFORMANCE FUNCTION DURING CONSTRUCTION

Construction and installation work may be executed by construction organisation directly or through contractors. Whether the work is done by the contractor or the construction organisation itself, the construction personnel should be responsible for the following activities:

- i. Supervision and control of departmentally executed work and works done by contractors;
- ii. To ensure that contractors are established at site in a controlled manner, in allocated areas and wherever required, to provide them with necessary site services, information and instruction regarding applicable industrial safety aspects;
- iii. To ensure that all works are carried out in accordance with specifications and drawings, QA requirements are implemented and installation checks are appropriate and in accordance with surveillance schedules;
- iv. Planning and monitoring the progression of work.

### A. Procurement

Only those contractors who are qualified and experienced to carry out the work should be selected and employed for construction/installation work of the plant. If information on qualified and experienced contractor is not available, the construction organization should prequalify contractors for various works and prepare a short list to whom tenders for concerned works should be issued. Before award of work, the prospective contractor should be briefed about special technical requirements including regulatory requirements.

### B. Start-up Meeting

After award of construction/installation contract a start-up meeting should be convened between the contractor and construction organisation to establish that contractor is fully aware of construction organization's requirements for aspects such as methods of communication, documents and information to be submitted, housekeeping, site security, mandatory site

training courses, safety (radiological, nuclear and industrial), QA, control of subcontractors, understanding of technical requirements etc.

### C. Review of Contractors' Quality Assurance Documentation

Construction organisation should request from contractor complete schedule of submission of documents required for approval, identifying each document by title, reference and date. Typical documents covered may include contractor's QA programme, inspection and test plans, installation methods, operator qualifications, special processes and work instructions. A history of review and approval of document submitted by contractor should be maintained both by the contractor and the construction organisation.

### D. Approval of Sub-Contractors and Suppliers

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

### E. Housekeeping during-Construction and Installation

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

Special attention should be paid for proper housekeeping during pre-assembling/installation and precommissioning of reactor components. Where clean zones are used to achieve the control, they should be clearly marked and instruction plated at the entrance as well as issued to regulate their access.

### F. Control of Materials and Equipment

All material and components received at site should be as per the overall plan of construction of the project. This planning should take into account the need for properly constructed (covered/open) storage areas, suitability of packing for long duration storage, etc. Receiving, storage and handling of equipments should be controlled through an established procedure to prevent their abuse, misuse, damage, deterioration or loss of identification.

### G. Measuring and Test Equipment

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

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

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

#### H. Verification of Construction Work

Verification schedules and checklists should be prepared by construction organisation which should identify the level of inspection/verification requirement. This verification schedule should be made available in advance to all concerned. Construction organisation should issue, where necessary, procedures with standard forms for recording of contractor's inspection/verification activities. The verification method and acceptance criteria should be clearly identified. Construction organisation should form a group of experts from construction, commissioning, QA and design to do integrated verification of completion of construction of the systems.

#### I. Handover and Transfer of Responsibilities

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

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

#### IV. QUALITY ASSURANCE FOR ASSESSMENT OF CONSTRUCTION ACTIVITIES

Assessment activities should be planned in advance and should be done at appropriate stages to assure quality, to provide confidence and to take timely corrective actions. Typical subjects for assessment by construction organisation should include: interfaces, safety management, material testing, contractor's audit procedures, training and qualification, housekeeping, preservation of completed work, generation, and maintenance of documents etc.

##### A. Self-assessment by Management

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

##### B. Independent Assessment

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

#### CONCLUSION

Since the inception of energy generation from radioactive fuel at nuclear power plant, safety of public and occupational workers and the protection of environment are assured by pursuing many regulations and standards. To make sure that nuclear power project satisfies such standards, quality assurance and quality control is implemented in every aspect of plant construction. If QA programme is effectively implemented then it will provide adequate confidence that system/item will perform in service as per specifications.

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