

Basic Study of Establishment of Quality Assurance Processes to Develop an Integrated Quality Assurance System for Nuclear Power Plant Construction

Lim, Byung-Ki^{a*}, Moon, Byeong-Suk^a, Lee, Jae Kyoung^a,
^aCentral Research Institute, Korea Hydro & Nuclear Power Co., Ltd.
^{*}Corresponding author: gamram@khnp.co.kr

1. Introduction

Quality assurance programs implemented by those who participate in nuclear power plant construction projects such as owners, Architect engineering, suppliers, contractors, and sub-contractors, are very important activities meant to improve the safety and reliability of nuclear power plants. An integrated quality assurance system has necessitated carrying out quality assurance programs in a systematic manner because the opportunities to expand business in overseas markets have increased since the export of a nuclear power plant to UAE in 2009. In this study, we use PDCA method to systematically analyze the quality assurance procedures that were used in previous projects for constructing nuclear power plants. We reached a classification system of quality assurance processes at each phase of nuclear power plant construction by integrating similar work related to quality such as planning, design, equipment manufacturing, construction and start-up. We also established a hierarchy of quality assurance processes to develop an integrated quality assurance system as a technology goal to be developed later.

2. Preliminary Review

2.1 Current Status in Foreign Countries

Westinghouse Electric Company has operated a quality assurance program to meet customer requirements and regulatory requirements specified in 10CFR50.55a of United States codes and standards related to nuclear power. Westinghouse's quality management system in operation is a process-based quality management system intimately interconnected to activities which affect quality throughout the lifecycle comprising project planning, design, procurement, production, inspection, and construction.

Hitachi-GE Nuclear Energy, Ltd. has structured a standardized quality assurance program with reference to ISO9001 and JEAC 4111-2003 (Quality Assurance Code for Safety in Nuclear Power Plants). All companies belong to Hitachi Group handle quality assurance activities in a planned and systematic manner when quality-related work needs to be carried out. In addition, Hitachi-GE's quality management system is applied to all phases in the lifecycle comprising product development, design, manufacturing, installation, start-up, inspection, and operation and maintenance in order to ensure safety and improve reliability of nuclear facilities.

According to GS-R-3(General Safety Requirement), issued by IAEA in 2006, GS-R-3 is provided to define requirements for establishing, implementing, assessing and continually improving a management system that integrates safety, health, environmental, security, quality and economic elements in order to ensure that safety is properly taken into account in all the activities of an organization. The structure of GS-R-3 is shown in Fig.1.

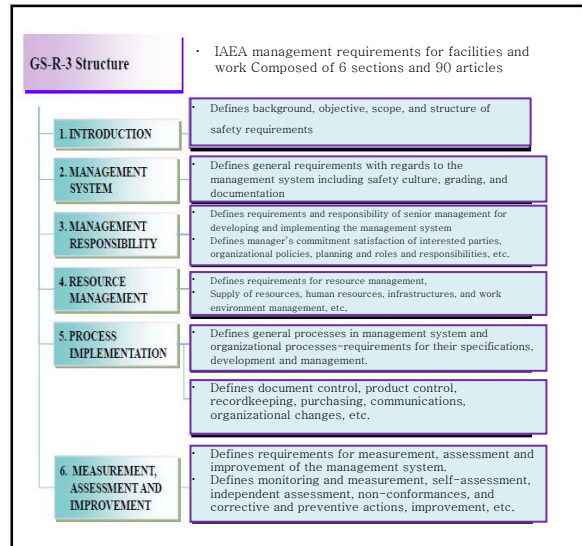


Fig. 1. Structure of GS-R-3

2.2 Current Status in Korea

Eighteen requirements specified in ASME NQA-1(KEPIC QAP) for the dedicated regulation of quality at nuclear power plants are applied to nuclear power plants in Korea and are in operation. Quality assurance system is in place to ensure quality at each phase of the life comprising construction planning, design, Construction, and maintenance and operation phases. Quality assurance activities are carried out by DREAMS (Digital Realtime Enterprise Asset Management System) which is oriented to quality assurance planning, control system for the quality of manufacturing equipment, and NPCMS (Nuclear Project Control Management System) which is oriented to equipment manufacturing inspection and equipment-acceptance inspection in the field. Each concerned party participating in a construction phase structures a separate quality assurance system and operates the quality assurance system.

3. Classification System of the Quality Assurance Process in Nuclear Power Plant Construction

3.1 Classification System Obtained by Using PDCA Cycle Method

Table 1 shows the result of analysis using PDCA cycle method to extract similarity in terms of work characteristics from quality assurance procedures which were used in preceding nuclear power plant construction projects. As shown in Table 1, all quality-related work procedures in planning, preparing, acting, reporting and taking countermeasures are described to check whether all requirements conform to the requirements in quality assurance plan ; and efficient quality activities for ensuring safety and for improving reliability of nuclear power plants

help us to find quality problems and guide us to appropriate solutions such as corrective actions to be taken to solve problems and ensure continuous improvement of quality.

Table 1: Result of PDCA analysis

Procedures	Plan	Do	Check	Act
Quality Assurance	Planning	Auditing	Writing checklist	Issuing CAR
Quality Surveillance	Planning	Auditing	Writing checklist	Issuing CAR
Assessment of Nuclear Power Plant Construction and Service Companies	Planning	Evaluating	Writing checklist	Result of Review
Assessment of Subcontractor's Quality Assurance Capability	Planning	Evaluating	Writing checklist	Recordkeeping
Review of Supplier's Quality Assurance Plan	Receiving documents	Document Review	Writing examination of the review	Recordkeeping
Assessment of Auxiliary Equipment Supplier	Receiving documents	Document Review	Writing checklist	Recordkeeping
Acceptance Inspection for Equipment	Storing incoming materials	Inspecting	Writing checklist	NCR, QDN,
Inspection of Storage Items and Storage Facility	Preparing inspections	Inspecting	Writing checklist	NCR, DDN
Quality Inspection of Manufacturing Equipment	Requesting for inspection	Inspecting	Writing checklist	NCR
Inspection of Construction	Planning inspection	Inspecting	Writing checklist	NCR
Inspection of Trial Operation	Planning trials	Inspecting	Writing checklist	Recordkeeping
Review and Approval of Documents Related to Quality	Request for review	Document Review	Writing checklist	Recordkeeping
Documentation and Control of Procedures	Request for review	Document Review	Writing checklist	Recordkeeping

3.2 Quality Assurance System at Each Nuclear Power Plant Construction Phase

Fig. 2 is a chart showing the quality management system at each phase in nuclear power plant construction with classification of quality-related works based on the result of PDCA Cycle analysis described in Table 1. At the planning phase of nuclear power plant construction, quality assurance activities are carried out to check whether quality requirements of site survey, quality assurance plan, documents for license and approval, quality procedures, etc. are appropriate. At the implementation phase of nuclear power plant construction consisting of design, procurement, equipment manufacture, acceptance inspection, construction, O&M phases, it is analyzed that quality inspection activities are carried out to check whether requirements of quality, technical standards and others are met. Finally, at the quality improvement, quality improvement activities are carried out systematically to prevent recurrence of problems by way of tracking, controlling overall status, and analyzing tendency of the implementation of appropriate corrective actions that are taken as requested when request for taking corrective actions is issued or non-conformance report is issued as the result of quality inspection activities.

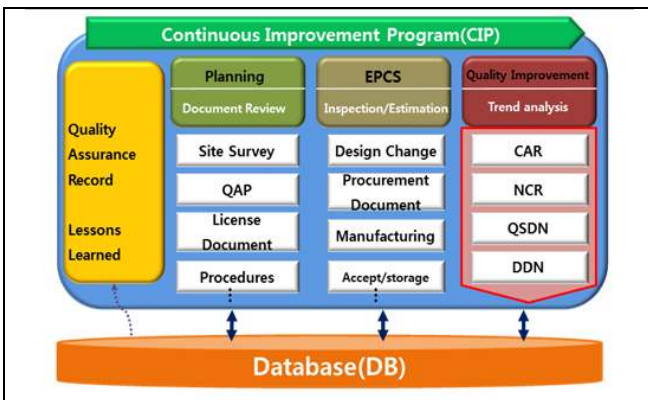


Fig. 2. Quality Assurance Process at Nuclear Power Plant Construction Phases

3.3 Classification of Nuclear Power Plant Quality Assurance Process

Table 2 shows classification of quality assurance processes at each phase of nuclear power plant construction to get activities performed at actual working level by defining hierarchy of unit processes such as quality assurance audit and quality supervision to develop an integrated quality assurance system. Quality assurance processes in nuclear power plant construction can be classified as Table 2 shown below.

Table 2: Classification of Quality Assurance Processes in Nuclear Power Plant Construction

LEVEL 1	LEVEL 2	LEVEL 3	Follow-up processes
Quality Assurance Activities	Quality assurance audits	Planning audits and notifying audits to be taken	Issuing and controlling request for taking corrective action
		Prepare audits	
		Writing audit checklist	
		Meeting prior to audit	
		Audit	
	Supervision of quality	Meeting after audit	Issuing and controlling requests for taking corrective action Issuing and controlling requests for providing supplementary quality actions Issuing and controlling non-conformance reports
		Report of audit	
		Planning	
		Writing checklist for auditing	
		Conducting audit of quality	
Assessment of capability of performing quality	Assessment of construction and service companies	Writing a report of audit	Recordkeeping of quality assurance documents
		Establishing assessment plan	
	Assessment of subcontractor's quality capability	Assessment	Recordkeeping of quality assurance documents
		Request for evaluating capability of quality	
		Examining documents	
	Assessment of quality of auxiliary equipment supplier	Submitting results	Recordkeeping of quality assurance documents
		Receiving documents for application of registration	
		Notifying examination of the application for registration	
		Examination of documents/ Examination at site	
		Writing check for document examination/ examination at site	
Review of quality documents	Review of supplier's quality assurance plan	Notification of results	Recordkeeping of quality assurance documents
		Request for reviewing quality assurance plan	
	Review of documents regarding quality	Review of quality assurance plan	Recordkeeping on quality assurance documents
		Request for reviewing quality documents	
Quality inspection	Receiving inspection of incoming equipment	Check requirements for quality documents	Issuing and controlling request for providing supplementary document for quality Issuing and controlling request for supplying supplementary document Issuing and controlling non-conformance reports
		Writing and notifying report of quality review	
		Request for inspection of receiving materials	
	Inspection of construction	Preparing inspection for receiving materials	Issuing and controlling non-conformance reports Recordkeeping of quality assurance documents
		Carrying out inspection of receiving materials	
		Writing reports of inspection of receiving material	
	Inspection of trial operation	Writing inspection plan	Issuing and controlling non-conformance reports Recordkeeping of quality assurance documents
		Notification of work	
		Carrying out inspection	
		Writing inspection report	
Quality Improvement	Issuing/Notifying non-conformance report	Writing request for running trial operation	Management on corrective actions taken
		Notifying trial operation	
	Issue a Request for submitting complementary documents	Carrying out inspection by participating in the trial operation	
		Writing reports on the inspection	
	Issue a request for taking complementary quality measures	Report of corrective action to be taken and result of corrective action taken	
		Handling of examination and result	

- 1) Level 1 : Level 1 is classified into quality assurance activities to check whether quality assurance system for nuclear power plant construction is implemented or not; assessment of quality system including quality system of nuclear power plant construction and service companies, and subcontractors; review of quality-related documents such as supplier's quality assurance plan and quality procedures; quality inspection for inspecting equipment manufacturing, construction, trial operation, etc. ; and quality improvement which can be classified as processes following up each quality assurance activities

2) Level 2 : To ensure independence and authority at the time of carrying out works affecting quality, Level 2 is classified into groups having similar work characteristics in quality assurance activities for the construction of nuclear power plant by considering: establishment and implementation of quality assurance plan; quality surveillance for writing checked results; and quality inspection. Quality inspection is divided into inspection of equipment manufacturing, acceptance inspection, inspection of construction, start-up in the light of phases of construction and production. Document reviews for license, approval, design change, procurement, and others are grouped together. Processes for evaluating quality assurance plan of a constructor, a service provider, and an auxiliary equipment supplier are classified into the assessment of performing quality assurance capability in the table. Finally, quality improvement is a follow-up process accompanied when non-conformance report, request for taking corrective actions, request for providing supplementary quality control documents, request for providing supplementary documents, and others are issued to manage and implement corrective actions to be taken.

3) Level 3 : Level 3 is classified as the level of activities to carry out actual works grouped as similar works from quality assurance activities. In order to structure the integrated quality assurance activities later on, sequence of work flow is identified; and levels are classified based on the ability for carrying out works related to information flow and data input/output.

4. Conclusions

To obtain most updated quality assurance activities, a quality assurance process is structured by integrating similar works analyzed from quality assurance procedures through PDCA cycle method. The result of this study, classified by phases of nuclear power plant construction consisting of design, procurement, equipment manufacture, *acceptance* inspection, construction, O&M and classified by similar works, will be used as a basis for developing the integrated quality assurance system.

At the implementation phase of Hierarchy of quality processes and sequence of processes for constructing nuclear power plant are established in this study. Integrated quality assurance system is to be developed by connecting organizations as well as stakeholders such as owners, Architect engineering, suppliers, contractors, and sub-contractors to carry out assigned work efficiently.

REFERENCES

- [1] Westinghouse, Quality Management System Revision 6 August 13, 2010.
- [2] Hitachi, Quality Assurance Activity Focused on Achieving Nuclear safety, 2009.
- [3] IAEA, The Management System for Facilities and Activities (Safety Requirement No. GS-R-3), 2006
- [4] B. K. Lim, H. S. Park, S. K. Won, Basic Study on Quality Assurance System for the Korean Nuclear Quality Process Development, AIK Presentation Vol 33. pp 575, Apr. 27, 2013