IMPROVEMENT OF QA/QC ACTIVITIES IN THE CONSTRUCTION OF NUCLEAR POWER PLANT

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ABSTRACT

Construction of commercial nuclear power plants in Japan started at around 1965. In this presentation are described quality assurance(QA)activities of a plant supplier who is a manufacturer of the key components as well. The QA activities until now are divided into several periods of the construction history in Japan. First term is 1960's when the QA activities are featured as the study and implementation through the construction of imported plants. Since then technologies and procedures of our own have been established and improved for the construction of high reliability plants. Our present QA activities are based on the active reflection of those lessons learned of past experiences.

I. FOREWARD

In recent years, nuclear power plants in Japan have been maintaining comparatively high level of availability. This situation is considered to be a result of continued reflection and improvement over past experiences through cooperation of all the organizations concerned such as plant makers, plant users (electric power companies) and government authorities.

For the construction of nuclear power plants in Japan it is a common practice for the electric power companies to enter into a turnkey contract with one of the typical plant makers who are at the same time the manufacturers of important components.

Therefore, it is one of the most important responsibilities for the plant maker to perform adequate QA activities covering the initial design through turnover of the plant in order to construct a high reliability plant. This paper describes the lessons learned since the early days and the current efforts on the QA activities of one of the plant makers in respect to nuclear power plant construction.

II. EVOLUTION OF QA FOR NUCLEAR POWER PLANTS IN JAPAN

QA activities for the nuclear power plants in Japan have evolved in line with that of the light water reacter (LWR) technologies as shown in Fig. 1.

II-1 1960's: Introduction of Foreign LWR Technologies

This period is the time when the U.S. plant suppliers of LWR were the prime contractor and Japanese makers manufactured equipment items and installed them at site serving as their subcontractors.

During this period the Japanese plant makers experienced the foreign QC techniques including:

- Vendor control method
- Prior study of fabrication sequence drawings for manufacturing processes
- Prior study of inspection processes by reviewing the operating and testing procedures
- Documentation and retention of manufacturing and inspection results

While the Japanese makers already at that time possessed high potential of capability for the quality of products, it was very helpful for the Japanese makers in establishing the systems that recognized the importance of documentation and recording and were viable with appraisal by any competent third party.

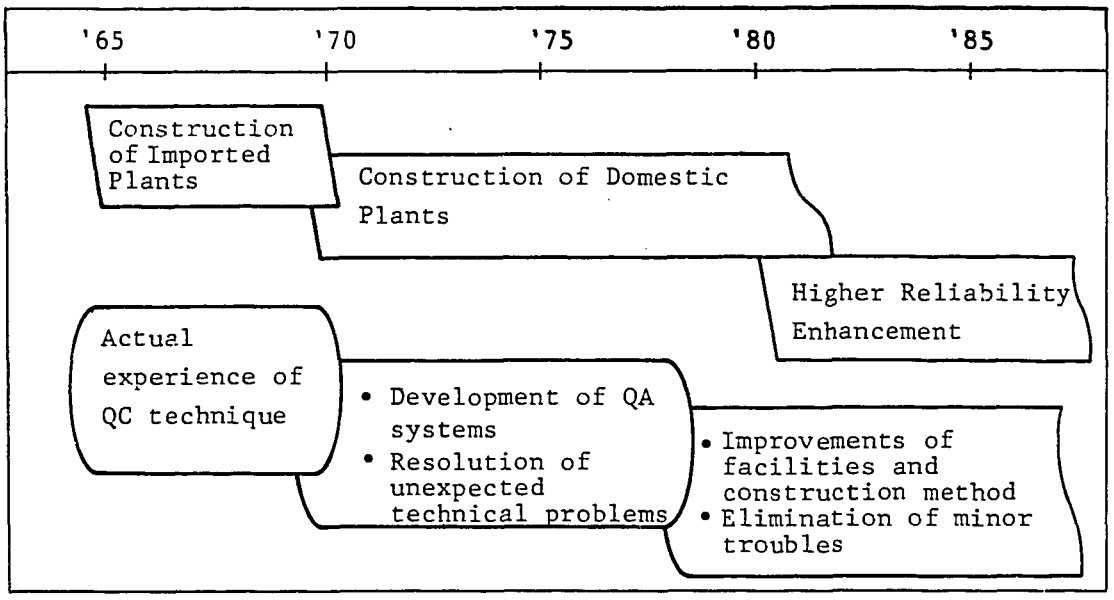

Fig. 1 History of the LWR technological improvements and QA activities in Japan

II-2 1970's: Construction of Domestic Plants

This period is characterized by the increasing adoption of Japanese made equipment items and the domestic plant construction as well as the introduction and development of the QA system learned from the USA. As an example, the Japanese industry guideline JEAG-4101 "Guide for Quality Assurance of Nuclear Power Plants" (1972) was issued in the wake of the 10 CFR 50 appendix B issuance in USA in 1971.

At present the industry QA guides as shown in Fig. 2 are issued corresponding to IAEA Code of Practice on QA and the safety guides.

In the meantime such unexpected technical problems as stress corrosion cracking of stainless steel piping, thermal fatigue cracking in the feed water spargers, cracking of fuel channels occurred during several years from about 1975. We resolved these problems with the support from the government authorities and the electric power companies. These problems were unanticipated ones and encouraged us to fully recognize the necessity of our own technological development.

. JEAG 4101	Guide for Quality Assurance of Nuclear Power Plants
. JEAG 4102	Guide for Establishing of the Quality Assurance Program of Nuclear Power Plants
. JEAG 4104	Guide for Quality Assurance in the Design of Nuclear Power Plants
. JEAG 4105	Guide for Quality Assurance in the Procurement of Items and Services for Nuclear Power Plants
. JEAG 4106	Guide for Quality Assurance in the Manufacture of Items and Site Construction of Nuclear Power Plants
. JEAG 4107	Guide for Quality Assurance in the Operation and Maintenance of Nuclear Power Plants (under preparation)
. JEAG 4108	Guide for Quality Records Control of Nuclear Power Plants
. JEAG 4109	Guide for Quality Assurance Auditing of Nuclear Power Plants

Fig. 2 Industry QA Guides for Nuclear Power Plants (Japan Electric Association)

While wrestling with the above problems, we had started the construction of the first domestic plant after finishing the blueprints of improved standard type plant based on the experiences gained through operation and maintenance of the early plants.
Under these circumstances our strenuous QA activities have been continuing to date which is composed of thorough inspection of the equipment items, enhanced work control system and experienced trouble retrieval system.

(1) Quality Assurance with Test and Inspection

Quality of nuclear power plant components is verified independently through multiple inspections by the government authorities, the electric power companies and the plant makers. (Fig. 3) Regulatory weld inspections, fuel inspections and pre-use inspections are performed in accordance with the MITI (Ministry of International Trade and Industry) Codes and Standards. In addition to the above regulatory inspections, the electric power companies perform their witness inspections for certain important points predetermined between them and the plant maker.

To fulfill the responsibilities as the plant maker, we are making efforts to foresee and clarify all potential questions prior to the confirmatory inspection by the electric power companies and the government authorities.

(2) Experienced Trouble Retrieval System

Various kinds of troubles experienced during plant construction to operation are stored and utilized in computer systems. Data in the computer is easily retrievable to the related engineers for improving their engineering and/or administrative activities. Fig. 4 shows the schematic diagram of our Trouble Retrieval System.

(3) Quality Assurance with Work Control System

Our QA programs are based on JEAG-4101 "Guide for Quality Assurance of Nuclear Power Plants" as mentioned above.
The most significant parts of these QA programs in conducting our QA activities are considered to be design management, manufacturing/installation control and procurement control.

(3)-1 Design Management

The design review procedure is of vital importance in the design management. Our program calls for the design review at the following stages from the planning to the completion of a plant.

Organizations	Inspections during Construction
Government Authorities	o Weld Inspection o Fuel Inspection o Pre-use Inspection
Electric Power Companies	o Pre-confirmation of Regulatory Inspections o Structural and Performance Inspection
Plant Makers	o Preparatory Inspection prior to Regulatory and Utility Inspections o Manufacturing Process Inspection

Fig. 3 Quality Assurance with Test and Inspection

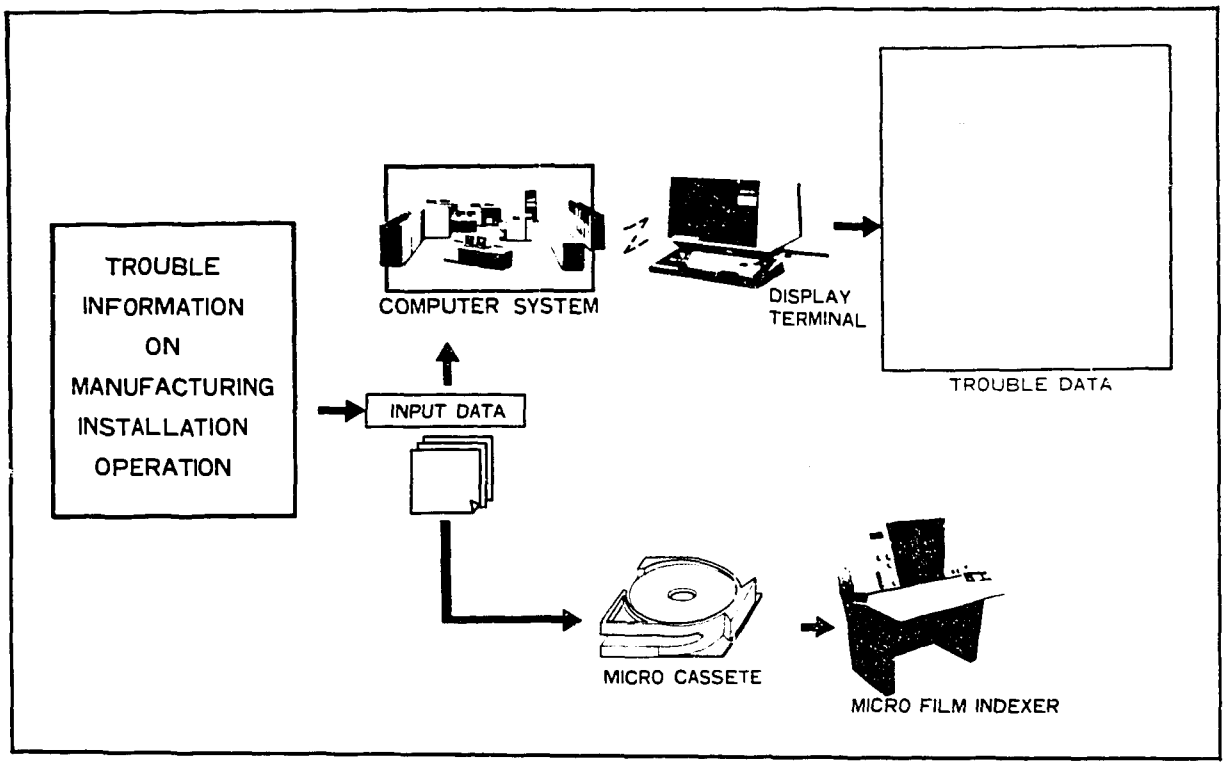

Fig. 4 Trouble Retrieval System

a) System and component design stage
b) Manufacturing and procurement stage
c) On-site installation stage
d) On-site test operation stage

Review activities performed at the above b), c) and d) stages are deemed as part of the design review for the purpose of "review on the planning of manufacturing and installation works" and "feedback of the results to the original design". The contents of the questionnaire for design stage review, for example, are categorized into the following general areas with detailed checklist.

a) Differences from previous plants
b) Confirmation of design suitability
c) Identification of problems

(3)-2 Manufacturing and Installation Control

Fundamental procedures for perfect manufacturing and/or installation are:

a) Preparation of the detailed work plan
b) Implementation of the work plan properly with checkup at each step of the work

A manufacturing or installation process is broken down into detailed work elements of the fabrication sequence diagram. All those work elements are covered by a process checklist to be used in the actual work and retained as record.

(3)-3 Procurement Control

In parallel with the ordinary procurement control procedure from placing purchase order to receiving inspection, the following two items are considered significant and effective for procurement of high reliability equipment items.

a) Evaluation of the suppliers with the first priority on their actual experiences
b) Information exchange between purchaser and supplier

A pre-production meeting on each of purchased equipment items will be held for the purpose of b) above after the supplier's production plan is fixed.
This meeting is regarded as a part of the design review at the equipment procurement stage and its main objective is mutual confirmation of the following items.

a) Specified performance and QA requirements of the equipment items
b) Design plan and manufacturing plan
c) Differences between the equipment items of the current plant and those of previous plant
d) Experienced troubles and their corrective actions

The various activities performed during the period of domestic technology through improvements over imported technology are considered to have solved major quality problems.

However, this situation did not mean the complete elimination of quality problems and we began to start the activities to tackle minor troubles and to enhance our technical capabilities toward the next period of technology enhanced for higher reliability with appropriate rationalization.

II-3 1980's: Higher Reliability Enhancement

From 1981 up to now, we have performed activities in various aspects such as given below for construction of high reliability plants in addition to the quality activities as described earlier in this paper.

- Improvements of plant facilities and fabrication/construction methods
- Overall check and review during construction of a plant
- Operating plant service activities

Fig. 5 shows the relationship among our QA activities and explains close linkage between our activities on operating plants and constructing plants for feedback of operating experiences.

(1) Improvements of Plant Facilities and Fabrication/Construction Methods

In order to improve the plant reliabilities we have made efforts to modify the design of the facilities such as the use of an advanced control system and integrated turbine trip instrumentation. As part of development in the fabrication and construction, we have adopted more improved methods like automatic welding and shop pre-fabrication technique at site.

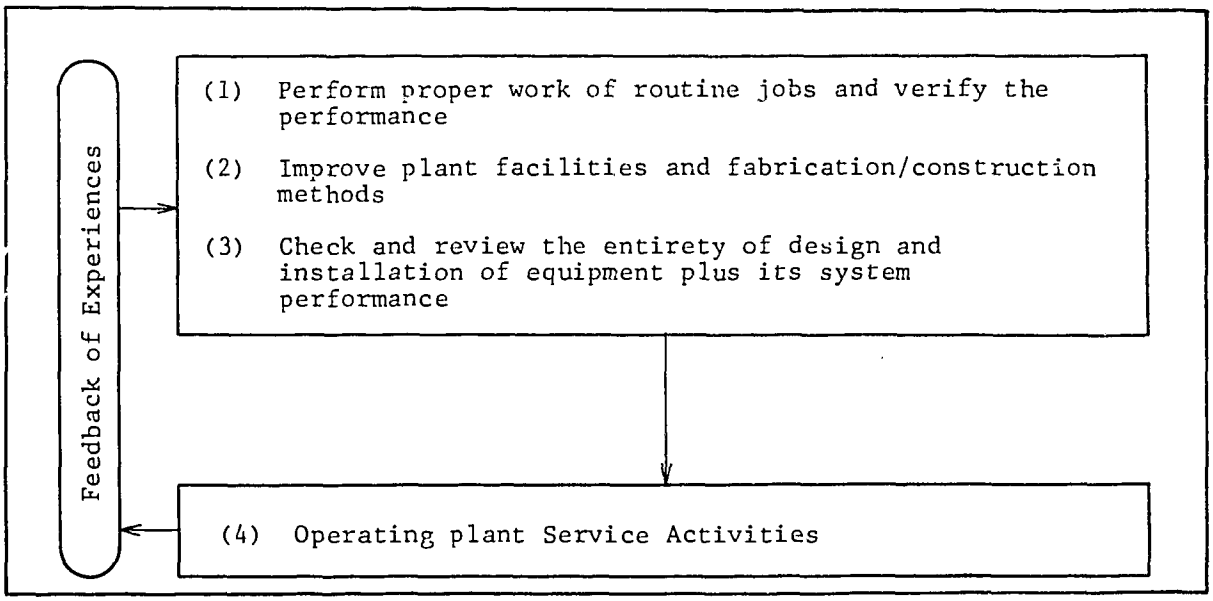

Fig. 5 QA Activities for Enhancement of Reliability

(2) Overall Check and Review of a Plant

In addition to the QA activities through routine jobs, we have established the repetitive checkup programs described below. Fig. 6 shows the meeting on this program to find out minor troubles that have escaped from the routine checking.

(2)-1 Reconfirm the Incorporation of Lessons from Experienced Troubles

Careful reflection of experienced troubles is one of the most significant approach to enhance the plant reliability. Major and minor troubles experienced are accumulated in our Experienced Trouble Retrieval System. A task force was formed to address all the troubles that have been retained in this system including other external information. The task force reconfirms the following items on each trouble by consulting with related engineers.

- Nature of the trouble
- Corrective actions taken
- Effectiveness of such actions

(2)-2 Procedure for Reevaluation of Design Changes

Considerable portion of troubles were found to be attributable to a change in design of systems/equipment from those of previous plants. Therefore, the changed systems/equipment are particularly reevaluated in terms of their effects on the plant operation. Reappraisal is made for the following items by related design engineers under the direction of the task force.

- Differences from previous plants
- Purpose of the change
- Suitability of the change

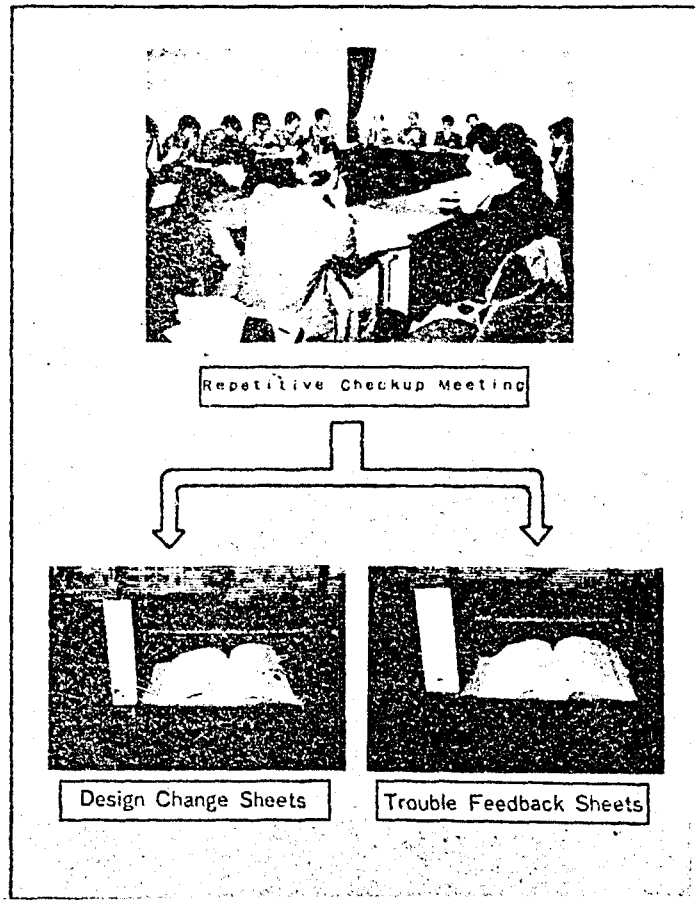

Fig. 6 The meeting on the repetitive checkup programs

In addition to the above design reevaluation procedure overall rechecking of installed equipment items at site is also performed by the task force members after each completion of their installation prior to fuel loading.

(3) Operating Plant Service Activities

Quality assurance activities by the plant maker is not limited to plants under construction but also extended to operating plants. Their purposes are to assist the electric power companies in improving their operating plants and to help resolve any troubles quickly.

Through these activities the plant maker has been obtaining information on operating plants and proposing improvement measures to the electric power companies. Accumulation of these activities are also intended to be utilized in reliability improvement of the plants under construction.

III. FUTURE WORK

As a result of our various aspects of QA activities from 1960's, our nuclear power plants have kept a high level of availability in recent years.
However, without being content with this level we are actively seeking to provide much higher reliability of commercial nuclear power plants in reasonable manners.
To this end we ought to always challenge our current practices like questioning:

(1) Is there any inadequacy and/or insufficiency in our QA activities?
(2) Is there anything superfluous or unreasonable in our QA activities?