Summary

The objective of peer review (hereafter, the review) conducted by the Japan Nuclear Technology Institute (hereafter, JANTI) is to promote the highest level of excellence in the operation, maintenance and support of operating nuclear power plants.

The "Performance Objectives and Criteria" (PO&Cs) used for World Association of Nuclear Operators (WANO) Peer Review were applied to the review as a standard.

These criteria are guidelines for leading the way to promote the highest level of safe and reliable nuclear power plant operation. In this review, they were used to identify "Strengths" and "Area for Improvement Needed" (hereafter, AFIN).

Strength is a significant beneficial practice, activity, or process employed by a station that results in achieving a high level of performance or desired high quality results and benefits. On the other hand, AFIN is a problem or vulnerability that needs to be resolved to enhance the ability of the station to safely and reliably operate the plant and to make and sustain future improvements. Identified AFIN is for worthwhile improvement from the standpoint of excellence, but does not always mean insufficient, inappropriate nor poor performance compared with industry standard.

1. Overview of the Reviewed Establishment

The JANTI review team conducted the review at Fukushima-Daiichi Nuclear Power Station (hereafter, the station) of Tokyo Electric Power Company (TEPCO) from Monday, January 16th to Friday, the 27th 2006. The station has six Boiling Water Reactors (BWR) in service.

Unit	Rated Electric Output (MWe)	Commercial Operation Started	Operating Performance (As of the end of January, 2006)	
			Electricity Generated ＊1 (100,000 MWh)	Capacity Factor＊2 (%)
1	460	March 1971	740	52.5
2	784	July 1974	1,313	60.0
3	784	March 1976	1,374	65.0
4	784	October 1978	1,327	69.6
5	784	April 1978	1,380	71.3
6	1,100	October 1979	1,796	70.3

＊1) Electricity Generated: Including test runs

＊2) Capacity Factor: Since start of commercial operation

The operating state of the station during the period of the review was: the unit 4 was unplanned shutdown due to the condenser problem, the unit 6 was in annual refuelling outage, and all other units were operating at their respective rated output.

2. Review Schedule

After reviewer training and preparations (from Wednesday, January 11th to Friday, 13th 2006) by the review team at the JANTI office, the review was carried out at the station for two-weeks from Monday, January 16th as shown in Table 1.

Table 1: Review Schedule at the Station

		Review Description
Monday, 16th	a.m.	・Entrance Meeting (introduction of the review team and the station counterparts, briefing of plant operating status and issues) (the beginning part was open to the mass media)
	p.m.	・Observation of plant equipment conditions, etc ・Schedule arrangements with the counterparts in each review area
Tuesday, 17th		・Observation of plant equipment conditions and field, interviews, document reviews, and exchanges of views on results with the counterparts ・Team meeting including station representatives
Wednesday, 18th Thursday, 19th Friday, 20th		・Field observations, interviews, document reviews, and exchanges of views on results with the counterparts ・Team meeting including station representatives
Saturday, 21st		Day off
Sunday, 22nd	a.m.	・Team meeting (to discuss Strengths and AFINs)
	p.m.	・Analyzing observations in each review area
Monday, 23rd Tuesday, 24th		・Field observations, interviews, and document reviews ・Discussing the causes and contributors of problems with the counterparts ・Confirming and discussing the facts concerning Strengths and AFINs ・Team meeting including station representatives
Wednesday, 25th		・Discussions with the counterparts in each review area ・Managing representative, the team leader and the station representatives to discuss Strengths and AFINs ・Team meeting including station representatives
Thursday, 26th		・Review and finalize Strengths and AFINs ・Preparing for the exit meeting
Friday, 27th	a.m.	・Exit meeting (review team to explain Strengths and AFINs and give supplementary explanations as requested by the station)
	p.m.	・Press conference organized by JANTI (at the station's Service Hall)

3. Review Methodology

3.1 Review Process

The review team conducted the review as described below, focusing on field observation and closely exchanging opinions with the counterparts in accordance with the INPO*[3] review methodology.

*3) INPO (Institute of Nuclear Power Operations) was established by the U.S. nuclear electric utility industry, following the Three Mile Island accident in 1979. It is an organization that is reviewing nuclear power stations in the U.S. periodically. The main process of INPO review is field observation conducted at station for two weeks, and the review for Fukushima-Daiichi Nuclear Power Station also employed this methodology. It is known world nuclear industry-wide that INPO has contributed a great deal to improve safety and reliability of U.S. nuclear power stations since the 1990s.

3.1.1 Collecting Information

First, all reviewers conducted plant walkdown and observed equipment conditions in the areas assigned to each of them. The number of white cards on which they wrote down issues they noticed during walkdown amounted to approximately 300. Some of the items written on the cards extend over several review areas. Sorting them out by applicable review area, there were approximately 130 cards in Operations area, about 150 in Maintenance, about 50 in Engineering Support, approximately 20 in Radiological Protection, and so on. These cards were distributed to each review area and used as a starting point of the review.

Subsequently, the review started in each area separately. Specifically small teams consisting of one to three reviewers were formed for each review area and observed plant equipment conditions and daily activities of the station personnel including employees of contractors. That is to say, each reviewer conducted field observations elaboratively in accordance with the review plan drawn up in advance, followed by interviews and document reviews. At this stage of the review, lots of observed facts including the results of interviews and document reviews were decided as significant based on the review standard (PO&Cs) and reviewer's experience recorded for further deliberation. The review team frequently exchanged opinions on these facts with the counterparts and employees of contractors, if necessary, during the process.

The results of the above activities were introduced and discussed if it should be determined as either excellent or problem based on each team member's experience and the best practice in the industry at the daily team meetings (held for an hour or two from 5:00 p.m.).

3.1.2 Analyzing Information

Reviewers in each area identified excellent and problematic practices in comparison with the review criteria (PO&Cs) among the results of observations, interviews, document reviews, feedbacks from the counterparts, and discussions at team meetings. Among these, excellent practices were put together as "Strengths" including the necessary information so as to provide reference for other stations.

On the other hand, the problematic issues were further analyzed and discussed to clarify what the problem nature was, why they occurred (analysis of the causes and contributors), and how they could be resolved (how to make improvement). When additional information was required in this process, additional field observations, document reviews, or interviews were conducted, and AFINs were developed based on analysis and evaluation of these facts.

AFINs including specific problem examples were explained to the counterparts with reference to the review criteria (PO & Cs) and industry best practices that reviewer acknowledged. Discussions were repeated until mutual understanding and recognition with respect to the nature, route cause, and contributors of the problems were attained.

The details of these discussions and the feedbacks from the counterparts were presented again at the review team meeting. All of the review team made further discussion and analysis about the validity and basis of Strengths and AFINs to brush up them in terms of accuracy and appropriateness from multiple aspects considering the feedbacks.at team meetings in order to

3.2 Review Scope

3.2.1 Reviewed Areas

In the review, six fundamental areas, from first to sixth area of following ten functional areas of the review standard (PO&Cs) were reviewed.

(1) Organization and Administration
(2) Operations
(3) Maintenance
(4) Engineering Support
(5) Radiological Protection
(6) Operating Experience
(7) Chemistry
(8) Training

(9) Fire Protection **(10) Emergency Preparedness**

3.2.2 Review Team Members

The review team (15 members plus two interpreters) consisted of:

Managing Representative: Matsushita, Director of JANTI
Team leader : Naruse, Director of JANTI
Team members : 14 persons under the team leader
(2 from INPO, 3 from JANTI member organizations and 9 from JANTI)

4. Outline of the Results

The following Strengths and AFINs were identified. However, these AFINs were not the kind necessitating immediate corrective actions to ensure nuclear safety.

4.1 Strengths

Strengths identified by the review team are the following three items.

[Engineering Support]

(1) The industrial safety handbooks developed by station, specialize in work where fire or dangerous substances are handled, which has been distributed to and used by the station personnel and employees of contractors.
This results decrease in the number of fire accidents in the workplace from three in FY 1998 to one for seven years since the handbook was published in March 1999 up until the present (January 2006).

[Organization and Administration]

(2) The station is actively participating to the "Leadership Development Training,"*[4] where communication techniques and improvement methods are lectured by external sources (overseas). This activity has brought remarkable improvement effects in various areas in the station by implementing the acquired methods.
Leadership Development Training has been implemented 17 times from August 2003 up to now, and not only have 115 station personnel attended, but nine employees of contractors have

also attended. As a result, the inspection know-how document is established and the method of analyzing environmental samples of strontium 90 is improved. These activities contribute to improve the effectiveness commonly for all three TEPCO nuclear power stations.

∗4) The Peach Bottom Nuclear Power Station owned by Philadelphia Electric Company (PECO) in the U.S. was ordered to halt operations by the U.S. Nuclear Regulatory Commission (NRC) in 1987 when it was exposed by a whistleblower that control room operators had dozed off.
As the foundation of the reform, attempts were made toward improving communication ability and awareness reforms, and PECO promoted internal reforms drafting a plan for LDE aimed at front-line leaders at the site as one of the main components.
This training program has been tailored to Japanese needs, and trainees of TEPCO were dispatched to the U.S. to attend the training.

(3) The station developed a system of actively providing information to contractors and receiving requests and improvement proposals from contractors, and makes continuous efforts to share information and maintain candid communications.
For example, inside the station premises there is an electronic bulletin board that displays information about things happening at the station, maintenance information and the like so that all station personnel including employees of contractors will be informed. Also, the station regularly holds information exchange meetings with the workers of about 450 companies (including second and third tier sub contractors) who work in the plant for the purpose of exchanging opinions and providing information about the station. Furthermore, the station regularly holds the Echo Committee that deals with every proposals and requests from contractors that are submitted into the improvement proposal box.

4.2 AFINs

On the other hand, 14 AFINs have been identified in five areas other than "Operating Experience" area.

[Operations]

(1) Operations management needs to establish and reinforce high standards of performance and expectations for some operations activities.
For example, shift turnover briefings were interrupted over and over by telephone calls, paging calls and contractor personnel asking to hand key over or workorder permission.

(2) A number of uncontrolled operator aids in the station including hand-written notes and postings of information should be removed, and information needed for operation should be controlled.
For example, there was an unauthorized handwritten memo on the diesel generator fuel oil transfer pump control panel stating that an annunciator will be present if the switch is in the "off" position.

(3) Housekeeping and equipment condition in many areas of the station do not meet management expectations or industry standards. Appropriate management is needed.
For example, in the unit 3 service building 250V battery room, the following items were observed: hydrometer parts, plastic containers, boxes of electrolyte, empty electrolyte boxes, and some boxes of measurement supplies and equipments.
Also, there was a heavy layer of dust on the unit 3 generator main seal oil pump, especially in the vicinity of the pump bearings.

[Maintenance]

(4) Maintenance management needs to establish high standards of performance and expectations for some maintenance activities and to make them known to all concerned maintenance personnel.
For example, electrical safety expectations are provided in specification documents for work on energized equipment; however, safety precautions for the prevention of electric shock such as no wearing of rings, necklaces, and other metal on the body during the activity at electrical cabinets are not defined in a specification document.

(5) Foreign materiel exclusion (FME) control around the refueling pool and in the turbine controls area should be reinforced.
For example, there were lots of bags of gloves and other protective clothing located in the FME area. There were also several loose pairs of gloves. These items were not listed on the FME log.

(6) Spare equipments and maintenance tools should be stored adequately and reinforced the control of them.
For example, the inside of the temporary housing for storage of turbine maintenance tools on the second floor of the unit 6 turbine building was not put in the order. Also in regard to lending the attachment/detachment transport lifters for the unit 6 power center circuit breaker, it is not indicated clearly in the order specifications, "Common Specifications for Work Order (Nuclear)", and there are no clear rules concerning the management of them.

(7) Necessary elements to conducting reliability centered maintenance (RCM) *5 and condition-based maintenance (CBM) *5 should be established. Although the station is transitioning away from time-based maintenance*5 towards condition-based maintenance, many shortfalls still exist, such as the shortage of data analysts and the concrete development plan is behind schedule.

For example, the motor-driven feedwater pump operates only a few days every cycle during start-up activities, yet the pump and motor are completely overhauled every 4th refueling outage after a short period of cumulative service.

*5) [reliability centered maintenance, condition-based maintenance, time-based maintenance]

Maintenance work is carried out at nuclear power stations in accordance with long-term concrete plans.

It is customary in Japan for regular maintenance to be carried out at predetermined fixed regular intervals of "once per every XX years" for each particular group of equipments (time-based maintenance).

On the other hand, it is the normal practice at nuclear power stations in other countries to make use of a program that evaluates the optimum maintenance method for each equipment (reliability centered maintenance) by evaluation of the importance of the equipment (degree of impact on the plant if the equipment was to malfunction) and by evaluating the past record of malfunctioning by the equipment and so on.

Among these, condition-based maintenance is a method whereby data monitored is collected while the equipment is in operation, and this data is used to predict the life span and the like of the concerned equipment, which is reflected in the maintenance plan, and this is one form of reliability centered maintenance.

Generally speaking, by making use of reliability centered maintenance, it is possible to reduce maintenance frequency of the equipment that are not necessarily required in order to maintain the reliability of the station, and at the same time, it is also possible to eliminate occurrences of equipment malfunction due to human error (mistakes in maintenance work) that may accompany such maintenance activities.

[Engineering Support]

(8) Some of the machinery and materials stored temporarily in the station have not been evaluated in terms of the impacts during seismic events. Consideration needs to be given to improve the management of engineering evaluation.

For instance, in a number of places in the station piping system, the weight load of the attached lead shield blankets have not been evaluated the impacts during seismic events.

(9) There is room for improvement in regard to the control of the storage and accumulation of combustible materials inside the plant, including the control room.
For instance, there were a large number of combustibles (documents, papers, and the like) in the main control room and there has been no assessment of the impact of the burning of these articles.

[Radiological Protection]

(10) Exposure dose rate postings of each worksite within the radiation controlled area of the station need to be reinforced.
For example, in unit 6, the digital indicator that showed the radiation exposure dose rate at 3C*[6] area where disassembly and maintenance work of the control rod drive mechanism was performed was faced to area 3B2*[7] used for carrying articles into the worksite. Therefore, the displayed dose rate was difficult to see from the workers who were in area 3C. There was no other indicator of radiation exposure dose rate in area 3C.

∗6) Areas having radiation exposure dose rate: at least 1.00 mSv per hour, surface contamination density: less than 40 Bq per cm^2, and density of radioactive substances in the air: less than 4×10^{-4} Bq per cm^3.

∗7) Areas having radiation exposure dose rate: at least 1.00 mSv per hour, surface contamination density (disassembled parts): less than 4 Bq per cm^2, surface contamination density (floor): less than 0.4 Bq per cm^2, and density of radioactive substances in the air: less than 4×10^{-5} Bq per cm^3.

(11) It is necessary to pay appropriate attention to prevention of contamination spread in radiation controlled area.
For instance, during disassembly and maintenance work at unit 6, a worker wiping off the control rod drive mechanism housing put contaminated rags on the tools on the tool shelf, and then he put three contaminated rags into a radioactive waste bag together. This could lead to the unnecessary spreading of contamination.

[Organization and Administration]

(12) Standards of performance and expectations on contractors for some activities within the station are too lenient, and there are cases when the standards and expectations are not clearly communicated. Improvement actions need to be enhanced.

For example, although posting at the entrance to the control rooms denoting a specific time for supplemental personnel requests and asking that interruptions be minimized during the turnover briefing, it was observed that station personnel entering to request keys or authorization to perform work during the turnover briefing.

(13) In order to improve the station performance, the management needs to establish higher standards of performance and expectations for some activities and thoroughly communicate and strictly enforce them to the station personnel and contractors.
For instance, procedure use at the worksites was not required in the maintenance work performed by contractors.

(14) In a number of areas, there were instances of insufficient standards in regard to industrial safety, lack of thoroughness, and unidentified and uncorrected issues. These could lead to personal injury or death to the workers, and consideration needs to be given to improvement.
For example, there were wires and bolts used for installation of equipment sticking up from the floor of the unit 6 turbine building.