I. Summary

1. Overview of the Reviewed Power Station

1.1 Overview

The Japan Nuclear Technology Institute (JANTI) conducted a peer review (review) at Tsuruga Power Station (station) of the Japan Atomic Power Company from Monday, March 3 to Friday, March 14, 2008. At the station, there are two units: Unit 1 is a Boiling Water Reactor (BWR) and Unit 2 is a Pressurized Water Reactor (PWR). During the review, Unit 1 was in rated thermal operation and Unit 2 was undergoing an outage.
As of the end of November 2007, the Power Station had 400 personnel, and there were 1,854 contractor employees.

Unit	Rated electric output (MWe)	Commercial operation commencement date	Operation performance (as of March 30, 2008)	
			Generated energy[*1] (billion kWh)	Capacity factor[*2] (%)
1	357	March 1970	81.49	67.4
2	1160	February 1987	174.35	80.1

*1) Generated energy: includes periods of operational testing

*2) Capacity factor: since commencement of commercial operation

1.2 Circumstances surrounding the station and its efforts to address them

The station is located north of Tsuruga City in Fukui Prefecture. It is on the tip of the Tsuruga Peninsula and faces Tsuruga Bay, a place of scenic beauty which has been designated as a national park.
The Japan Atomic Power Company was established in 1957 to engage exclusively in atomic power generation, with the objective of pioneering the atomic power generation business. In 1966, the company commenced commercial operation of the Tokai Power Station, the first commercial reactor in Japan; this reactor employed a carbon dioxide gas cooled reactor loading natural uranium fuel. This marked the beginning for the company, as it gradually accumulated experience in BWR and PWR construction and operation. It has been a pioneering business in Japan, working for 50 years to develop and expand nuclear power generation technology.
Construction of Tsuruga Unit 1 began in April 1966; it was built to be the first commercial light-water reactor in Japan. This BWR commenced commercial operation in March 1970. Tsuruga Unit 2 is the first improved and standardized PWR with a capacity of one million kilowatts, which incorporated the best technology that Japan had to offer in its construction. It consolidated all of Japan's operational experience at the time, and improved safety and reliability through the addition of various equipment improvements.

At the station, a variety of equipment improvements have been implemented from the standpoint of improving safety and reliability. For example, during the 16th outage for Unit 2 which began in August 2007, the reactor vessel head and low pressure turbine were replaced with a new one using materials resistant to stress-induced corrosion at nozzle stubs of the vessel head as well as at the wing attachment of the low pressure turbine, as preventive maintenance measures in light of events related to stress-induced corrosion cracking which had occurred both in Japan and in other countries. Moreover, the high pressure turbine was also replaced along with the low pressure turbine replacement, to improve maintainability when inspecting steam turbines. Also, since flaws resulting from stress-induced corrosion cracking in the steam generator intake nozzle weld were identified, work is currently being undertaken to apply a series 690 nickel-based alloy coating to the surface perimeter, as it eliminates flaws and is resistant to padding and stress-induced corrosion cracking.

The station had been working on a subsurface and geological survey in order to evaluate seismic safety based on the new seismic standards agreed upon in 2006; however, in light of the Niigataken Chuetsu-oki Earthquake which occurred in July 2007, a general assessment based on seismic motions observed at the Kashiwazaki-Kariwa Power Station was released in September 2007. With regard to the seismic safety evaluation, an interim report was made regarding major facilities and equipment in March 2008. The seismic safety evaluation is scheduled to be completed by March 2009 for all facilities and equipment targeted for evaluation.

At the station, the specific operational targets cited are "zero industrial safety accidents" and "safe and stable operation." An effort is being made to spread the idea of safety first as the highest priority among station employees, which include contractor personnel.

Preparatory work is currently being implemented for construction of Units 3 and 4, which will be Advanced Pressurized Water Reactors (APWR) with an electrical output of 1.538 kilowatts. Construction is scheduled to being in 2010, and Units 3 and 4 are expected to commence operation in 2016 and 2017, respectively.

2. Review schedule

After reviewer training and preparations at the JANTI office from Wednesday, February 27th to Friday, February 29th, the review was conducted at the station for two weeks from Monday, March 3rd to Friday, March 14th, as shown in Table 1.

Prior to the review, field observations were conducted to observe field works including preparations during an outage of unit 2 at the station for the three days from Monday, November 5 to Wednesday, November 7, 2007 (outage observations).

Also, on Tuesday, January 15th and Wednesday, January 16th, 2007, operations shift crew performances during training were observed at the full-scope simulator facility of the BWR Operator Training Center (Fukushima Center) (simulator training observation).

Table 1: Review schedule at station

		Review Description
March 3 (Mon.)	(Morning)	・Entrance meeting (introduction of review team, review plan, etc.) ・Schedule arrangement with the station counterparts in each review area

	(Afternoon)	・Plant inspection to observe plant equipment conditions, etc.
4 (Tue.)		・Plant inspection to observe plant equipment conditions, field observations, interviews, document reviews and discussions about these results with station counterpart ・Team meeting including station representatives
5 (Wed.) 6 (Thu.) 7 (Fri.)		・Field observations, interviews, document reviews and discussions about these results with station counterpart ・Team meeting including station representatives
8 (Sat.)		Day off
9 (Sun.)		・Team meeting (refine strengths and areas for improvement)
10 (Mon.) 11 (Tue.)		・Field observations, interviews, document reviews ・Discuss causes and contributors related to problem areas with station counterpart ・Confirm and review facts related to strengths and areas for improvement ・Team meeting including station representatives
12 (Wed.)		・Discussion with station counterpart in each review area ・Discussion between team leader and station representatives regarding strengths and areas for improvement ・Team meeting including station representatives
13 (Thu.)		・Review and finalization of strengths and areas for improvement ・Discussion among exit representative, team leader and station representatives on strengths and areas for improvement ・Compile material for exit meeting
14 (Fri.)	(Morning)	・Exit meeting (explanation from review team regarding strengths and areas for improvement, as well as supplementary explanations when requested by the station)
	(Afternoon)	・Press conference organized by JANTI (at Tsuruga Nuclear Power Hall)

3. Review methodology and review scope

The objective of the review conducted by JANTI is to promote further improvements in the safety and reliability of the nuclear power stations.

3.1 Review methodology

The Performance Objectives and Criteria (PO&C) used by the WANO*3 (World Association of Nuclear Operators) were applied to the review as a standard. Besides the WANO standards, INPO*3 (Institute of Nuclear Power Operations) has also set down its performance objectives and criteria. However, since JANTI and WANO have implemented reviews with each other and the relationship is mutually complementary, the continuity of both organizations' peer reviews was taken into consideration in adopting the WANO PO&C.

This standard was formulated as a guideline to promote the highest level of the performance of nuclear power plant operations. In the review, the PO&C was used to identify "strengths" and "areas for improvement (AFI)". Strengths are items which have been judged to have reached the highest level possible. On the other hand, AFI are items for which effort is required to reach the highest level possible, but does not always mean insufficient, inadequate nor poor performance compared with industry standard.

The review team conducted the review as described below, focusing on field observation and closely discussing with the station counterparts in accordance with the INPO and WANO review methodology.

*3) WANO was founded in 1989 by nuclear operators world-wide, after the 1986 accident at the Chernobyl Nuclear Power Plant made it painfully clear that a global information network of nuclear power utilities was needed. Its mission is to improve the operational safety and reliability of nuclear power stations to the greatest extent possible, by implementing a variety of support activities for nuclear power stations. These include reviews of nuclear power stations throughout the world, as well as exchanging information concerning accidents and problematic events.

INPO was established by the US nuclear power industry after the 1979 accident at Three Mile Island nuclear power station. Regular review of US nuclear power stations is one of INPO's principal activities, and these are mainly accomplished by staying at the nuclear power station for two weeks and conduct on-site observations. The JANTI review follows this method. Since 1990, the contributions of INPO are recognized as being among the most extensive from those involved with nuclear power in improving safety and reliability at US nuclear power stations.

3.1.1 Information gathering and analysis

Reviewers for each area analyzed the information provided by the station in advance, which included: in-station operating experiences, procedures, meeting minutes, and outage observations and simulator training observations developed by JANTI. This is in order to prepare a review plan for effective implementation of station review.

3.1.2 Observations of equipment and facility conditions at station

First of all at the station, all reviewers conducted plant walkdown and observed equipment conditions in the areas assigned to each of them and noted any issues noticed. The number of collected issues were 444 total. When sorted by appropriate review area, there were approximately 160 issues in operations; approximately. 130 in maintenance; approximately 90 in engineering support; and approximately 90 in radiation protection. These records were classified by target review area and assigned to the reviewer responsible. Each reviewer utilized these records as material to understand the current situation of the station for the subsequent review. Since the content of many items falls under several categories, the sum of all categories is greater than the total number of items.

3.1.3 Field observations and follow-up

Two or three reviewers assigned to the specific review area started observations of the condition of the station facilities and equipment, and performance and behaviour of station personnel including contractor employees from a point of view of expert after conducting plant inspection. Then, they made interviews and reviewed documentation to follow-up the results obtained through detailed observations according to the pre-developed review plan. Each reviewer decided whether the gathered information was significant or not based on the review standard (PO&Cs) and their own practical experience. The significant facts identified as beneficial or problematic were recorded and noted as the issues need further evaluation. Each reviewer exchanged opinions about these facts with station counterpart and, if necessary, employees of contractors over and over.

The results of the aforementioned were presented at the evening review team meeting (approximately lasting one hour), and matters considered as excellent or problematic were deliberated by all members of the team.

3.1.4 Analysis of observation results

Reviewers for each area identified the excellent points and problematic issues according to the review standard (PO&C) from among matters gathered through the processes listed in 3.1.1, 3.1.2, and 3.1.3.

The excellent points were consolidated as "strengths," and information about them were included so that other stations may use them as reference.

The problematic issues were further analyzed to clarify what the problem nature was, why they occurred (causes and contributors), and how they could be solved (how to make improvement). In cases where additional information was required for this work process, additional field observations, document reviews, or interviews were conducted once more, and AFI were developed based on the results.

AFIs including their nature, cause and contributor were presented to the station counterparts with reference to the PO&C and actual industry best practices. Discussions were repeated until a mutual understanding about the nature of the problem, the cause, and the background.

The details of these discussions and feedbacks from station personnel were presented again at the review team meeting. All of review team member made further discussion and analysis in order to brush up strengths and AFIs in terms of accuracy and appropriateness from multiple perspectives considering the feedback.

3.2 Review Scope

3.2.1 Review Areas

In the review, six functional areas listed in (1) through (6) below were reviewed. The other areas (7) through (10) were reviewed as required as part of six functional areas.

(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 Composition

The review team consists of:

Exit Representative:	Matsushita, Director of JANTI
Team Leader:	Kawashima, Director of JANTI
Team Members:	19 members including team leader

(2 WANO personnel; 2 JANTI member organization personnel; 15 JANTI personnel)

4. Summary of results

The following strengths and AFIs were identified by the review team.

4.1 Strengths

The following nine strengths were identified:

[Operations]

(1) The "Operator's Essential Handbook" is utilized for the purpose of improving operators' knowledge of plant facilities, equipment, and operating procedures. Also, the "Compilation of Outage Summaries" is used to promote understanding of the content of outage work, as well as to pass on the tribal knowledge related to operating procedures for outage work. For example, the "Operator's Essential Handbook" was prepared after test operation of the plant, and includes information regarding major control systems and their limits, important interlocks, characteristic curves, and operational performance. Operators carry this handbook at all times and use it for operational procedures.

(2) In order to prevent human error, plant operation and shutdown work is classified by degree of importance, with management administered accordingly. Specifically, important steps from the point of view of reactor safety, as well as anticipated human errors and their effects are examined for each type of work. Management is exercised accordingly.

[Maintenance]

(3) As part of efforts to improve maintenance-related knowledge and skills of engineering center personals necessary to conduct maintenance work by themselves, Training programs combining OJT and General Training Center training are being implemented. Also, a personal record on training status and certifications acquired is kept on each engineering center personnel. This program has made contributions to the implementation of high-quality field work.

(4) Equipment diagnosis with a vibration measurement program is being implemented by station personnel who hold US certification; this has contributed to maintaining the soundness of rotating machinery. Said program includes the use of the latest diagnostic apparatuses, thorough data analysis, and frequency monitoring.

[Engineering Support]

(5) As a pioneer among Japanese nuclear power operators, many proprietary technology have been developed and applied to the plants, as well as reflect the in-house operating experiences acquired in other their own reactor types. For example, the world's first a laser irradiation stress improvement method was applied to the Unit 2 pressurizer nozzle; unit 2 became a world's first PWR to implement high pH operation.

(6) Mid-level employees have a training program named JAPCO engineering school. Instructors of the training consist of knowledgeable people who have worked at stations many years and have experience in station construction, and they pass their tribal knowledge gained while at the Tokai Power Station or during construction of the Tsuruga Power Station. This effort has contributed significantly to enhancing the engineering capability of employees.

In this training, weekly courses lasting approximately two hours have been held throughout the year (20 classes held in 2005, 24 in 2006). A total of 40 employees have taken the course as of present.

(7) The reactor engineering management provides explanations of core characteristics to all operators after the start up of each cycle. These explanations focus on the characteristics of the core components for that cycle, as well as the impact of control rod operation on core characteristics. These explanations have not only improved operator knowledge, but communication between operators and reactor engineers.

[Radiological Protection]

(8) The reliability and convenience of radiation dose control via Electronic Personal Dosimeters (EPD) has improved through improvements that reflect past non-conformities and contractor requests. For example, the EPD dose display window was moved from the front to the top, which has allowed dose verification while the EPD is still in their pocket.

[Organization and Administration]

(9) Proactive efforts have been made to ensure industrial safety through activities for "safety coaching" and the "safety action troops." This is in addition to the Health and Safety Promotion Council patrols, and the special patrols whose implementation frequency changes for ordinary operation and during periods of outage. The "safety action troop," where young employees follow personnel with vast experience in industrial safety, and "safety coaching," where senior experienced personnel sit in on work procedure instruction hearings, are both particularly unique. They have contributed to boosting worker safety awareness.

4.2 Areas for improvement

The following 15 areas for improvement were identified.

[Operations]

(1) Operations management (Operation Department) does not establish the high levels of expectation for panel monitoring, high level of circumstance in the main control room, roles and responsibilities of each operators so on. Moreover, operations management does not address issues in order to conduct operation

in adequate manner. For example, during an outage, approximately 20 people, including operators, outage implementation group personnel, and workers, were observed to be in the main control room of Unit 2. This created a situation in which it was difficult to concentrate on operational procedures and monitoring.

(2) There are numerous uncontrolled warning labels, diagrams, handwritten memos, and instrumentation markings in the main control room. For example, there was a laminated diagram posted on the Unit 2 T/B 1st Floor condensate demineralizer instrument panel. However, there was no indication of its date of posting or its control number.

(3) There are several objects affecting operations work or are unfavorable housekeeping issues in the plant. For example, during outage, cardboard boxes and other articles were temporarily stored in the Unit 2 T/B, approximately one meter from the station's internal air-compressor control panel. Moreover, an operator unintentionally made his hoot contact to these temporarily stored articles during the air-compressor start-up and shutdown.

(4) Simulator trainings are not implemented in effective manner in order to further reinforce operator's performance. For example, it might reduce the effectiveness of the training that trainees are aware of training events beforehand, because they will be able to anticipate the operations and items to be verified in advance.

[Maintenance]

(5) Foreign material exclusion measures around disassembled equipments and the spent fuel pool are inadequate. For example, on the 3rd Floor of the Unit 2 T/B, there were clear plastic bags for collecting flammable waste left inside a foreign material exclusion controlled area.

(6) Performance monitoring and diagnosis using infrared thermography are not conducted in daily equipment abnormality detection. For example, routine thermography diagnostic technology is not utilized for battery rechargers, inverters, motors, or switchgears.

(7) Improvements are necessary for the many corroded pipes, corroded supports, and damaged insulation. For example, the lower part of the Unit 2 auxiliary sea water strainer intake piping is corroded. Also, on the insulation for the Service Building diesel-driven fire pump intake line, there are dents which appears to have been made by someone stepping on it.

[Engineering Support]

(8) There are several articles not secured or tied down in the vicinity of important equipments and facilities vital to the safety and reliability of the station. For example, in the safety system inverter room, there is an unsecured tool rack was placed approximately 1.2m from the recharger board.

(9) Improvements are necessary for control of the volume and location of combustible materials stored inside buildings and the functionality of fire doors are not adequate. For example, there were combustible materials under a control cable tray, and electric cable reel placed in front of the fire door prevented them from closing.

[Radiological Protection]

(10) Improvements are necessary in radiation dose control particularly in storing high-dose materials, signs of dose equivalent rates, and worker's inappropriate behavior to reduce collected dose. For example, there were lead-shielded high dose drum cans temporarily stored in a controlled area, right next to the safety passageway.

(11) Control of the contamination monitoring and worker's behavior from a point of view of radiological protection are inadequate. For example, during repair work in the controlled area, there was a worker who did not take off their protective wear according to procedure when they left the contaminated area.

[Operating Experience]

(12) Collection and analysis of OE information are not conducted in the systematically integrated manner. For example, the current non-conformity database divided by the group responsible is unable to refer entire database all together.

[Organization and Administration]

(13) Organization-wide efforts to promote excellence in human performance are insufficient although station senior management seems to be aware of its importance from a point of view of crisis management. For example, it was confirmed that, although assessment and examination of human errors and near misses were conducted by the respective department committees, an overall assessment of the power station was not made.

(14) There is a need to clearly define and strictly pursue a high standard of expectation to improve work safety. Inappropriate state of lifting work and use of personnel protective equipment were observed. For example, workers passed under a load held up by a crane during lifting work, and engaged in cutting work or work in high-noise environments without wearing protective glasses or earplugs.

(15) There are cases where high standards of expectation were either non-existent or not thoroughly implemented through station personnel including contractors in the areas of operations, maintenance, engineering support and operation experience. Station senior management and managers must clearly define the standards and expectations, appropriately monitor and observe station performance, and improve their efforts for problem resolution. For example, station performance indicators to understand and continually assess current station status are hardly monitored by managers.