NRC'S RESPONSE TO THE FEBRUARY 15, 2000, STEAM GENERATOR TUBE RUPTURE AT INDIAN POINT UNIT 2 POWER PLANT

CASE NO. 00-03S August 29, 2000

OFFICE OF THE INSPECTOR GENERAL
EVENT INQUIRY

NRC'S RESPONSE TO THE FEBRUARY 15, 2000,
STEAM GENERATOR TUBE RUPTURE
AT INDIAN POINT UNIT 2 POWER PLANT

CASE NO. 00-03S

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August 29, 2000

MEMORANDUM TO: Chairman Meserve

FROM: Hubert T. Bell **/RA by David C. Lee Acting For/**
Inspector General

SUBJECT: EVENT INQUIRY - NRC'S HANDLING OF ISSUES ASSOCIATED WITH THE FEBRUARY 15, 2000, STEAM GENERATOR TUBE RUPTURE AT INDIAN POINT UNIT 2 POWER PLANT
(CASE NO. 00-03S)

Attached is an Office of the Inspector General (OIG), U.S. Nuclear Regulatory Commission (NRC), Event Inquiry concerning the NRC'S handling of issues associated with the February 15, 2000, steam generator tube rupture at Indian Point Unit 2 Power Plant. This inquiry was initiated to address concerns raised by the public and Congress as a result of the steam generator tube rupture.

Please call me if you have any questions regarding this Event Inquiry. This report is furnished for whatever action you deem appropriate. Please notify this office within 90 days of what action, if any, you take based on the results of this Event Inquiry.

Attachment: As stated

cc w/attachment: Commissioner Dicus
Commissioner Diaz
Commissioner McGaffigan
Commissioner Merrifield
William D. Travers, EDO

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BASIS AND SCOPE

The Office of the Inspector General (OIG) initiated this inquiry to address concerns raised by the public and Congress as a result of a steam generator tube rupture at the Indian Point Unit 2 Power Plant (IP2). The licensee of IP2 is the Consolidated Edison Company of New York, Inc. (ConEd). On February 15, 2000, IP2, a pressurized water nuclear reactor plant, experienced the steam generator tub rupture in one of its four steam generators. This rupture which resulted in a leak, allowed radioactive water which acts to cool the reactor, to mix with nonradioactive water in the steam generator. The nuclear reactor was manually shut down. This event led to IP2 declaring an "Alert" which is the second level of emergency action in the U.S. Nuclear Regulatory Commission (NRC) required emergency response plan. The February 15, 2000, event resulted in a minor radiological discharge to the atmosphere. Subsequent to the steam generator tube rupture, there were concerns that the NRC was aware of previous problems with IP2's steam generators and did not take adequate action to have the problems corrected.

This OIG Event Inquiry addressed three issues regarding the IP2 steam generator tube rupture. The first issue reviewed was the adequacy of the NRC staff's handling of actions by IP2 associated with the steam generator tube rupture. The second issue involved a review of the NRC's handling of shortcomings identified in the IP2 Emergency Preparedness Plan. The third issue addressed in this OIG inquiry relates to the adequacy of the NRC staff's review of the ConEd proposal to restart IP2 after the February 15, 2000, shutdown.

CHRONOLOGY OF SIGNIFICANT EVENTS

DATE	EVENT
August 1, 1974	NRC issues operating license to Indian Point Unit 2 Nuclear Power Plant (IP2), a pressurized water reactor (PWR).
October 1989	IP2 receives four new steam generators from Westinghouse. IP2 reports intent to change out steam generators in the early 1990s.
August 6, 1990	NRC issues Information Notice 90-49, "Stress Corrosion Cracking in PWR Steam Generator Tubes," to inform licensees of PWRs of recent problems involving stress corrosion cracking in PWR steam generator tubes.
August 3, 1994	NRC issues SECY 94-202, "Issuance of an Advanced Notice of Proposed Rulemaking on Steam Generator Maintenance and Surveillance," to inform the Commission of proposed steam generator rulemaking.
August 30, 1994	NRC issues Information Notice 94-62, "Operating Experience on Steam Generator Tube Leaks and Tube Ruptures," to inform licensees of PWRs of recent operational experience with steam generator tube leaks and tube ruptures.
April 28, 1995	NRC issues Generic Letter 95-03, "Circumferential Cracking of Steam Generator Tubes," to alert licensees about the importance of performing comprehensive examinations of steam generator tubes using appropriate inspection techniques and equipment capable of detecting degradation.
August 3, 1995	NRC issues Generic Letter 95-05, "Voltage-Based Repair Criteria for Westinghouse Steam Generator Tubes Affected by Outside Diameter Stress Corrosion Cracking," to licensees on alternate steam generator repair criteria applicable.

September 20, 1995	NRC issues Information Notice 95-40, "Supplemental Information to Generic Letter 95-03, 'Circumferential Cracking of Steam Generator Tubes'" to licensees discussing steam generator tube examination results from Maine Yankee Atomic Power Station. IN 95-40 provides findings of a comparative analysis of various techniques used in the examination and compares the sensitivity of a high frequency eddy current probe to a standard eddy current probe in the detection of inner diameter cracking.
June 21, 1996	NRC issues Information Notice 96-38, "Results of Steam Generator Tube Examinations," to inform licensees of PWRs about current results of steam generator examinations and the importance of controlling and optimizing test variables such as probe design and frequencies for inner diameter initiated indications versus outer diameter initiated indications.
April 9, 1997	NRC approves IP2 license amendment number 189 to allow an extension of the steam generator inspection interval from April 14, 1997 to May 2, 1997.
May 19, 1997	NRC issues Information Notice 97-26, "Degradation in Small-Radius U-Bend Regions of Steam Generator Tubes," to inform licensees of PWRs about recent degradation affecting the small radius (Rows 1 & 2) U-bend regions of tubes in recirculating steam generators.
June 30, 1997	IP2 restart is initiated following steam generator tube inspection.
July 8, 1997	NRC Office of Public Affairs issues "Technical Issues Papers and Fact Sheets: Steam Generator Tube Issues" which serves to focus attention on the significance of steam generator tube integrity, the need to be vigilant in monitoring steam generator tube degradation, and the importance of inservice inspections of steam generators.
July 29, 1997	IP2 submits their 1997 steam generator tube inspection report to the NRC.
October 25, 1997	IP2 is shutdown for an unscheduled maintenance outage.
December 16, 1997	NRC issues Information Notice 97-88, "Experiences

	During Recent Steam Generator Inspections," to inform licensees of PWRs about findings from recent inspections of steam generator tubes and secondary-side internal components.
July 24, 1998	NRC issues Information Notice 98-27, "Steam Generator Tube End Cracking," to inform licensees of instances of steam generator tube-end cracking.
August 5, 1998	IP2 restarts operation after being in cold shutdown condition for 304 days.
December 1998	NRC issues Draft Regulatory Guide DG-1074, "Steam Generator Tube Integrity," to provide guidance about steam generator tube integrity.
December 7, 1998	IP2 submits license amendment number 201 to the NRC requesting to modify its technical specifications to allow a one-time extension of the steam generator inspection interval from June 13, 1999 to June 13, 2000.
May 5, 1999	NRC issues a request for additional information (RAI) regarding IP2's license amendment number 201.
May 12, 1999	IP2 submits its response to NRC's RAI.
June 9, 1999	NRC approves IP2 license amendment number 201 to allow an extension to the steam generator inspection interval to coincide with the year 2000 refueling outage and, NRC approves the removal of the requirement that IP2 receive NRC concurrence on proposed steam generator examination program.
February 3, 2000	Main steam line radiation monitors register leakage from steam generator number 24.
February 6, 2000	The leakage monitor alarms indicating a 1.5 gallons per day (gpd) leak rate from steam generator number 24.
February 10, 2000	Leak rate trend shows leakage has increased to 3.5 gpd.
February 15, 2000	7:15 p.m. - The steam generator number 24 leakage

	monitor shows a leak rate of 3.4 gpd.
February 15, 2000	7:17 p.m. - Both the steam generator number 24 leakage monitor and condenser air monitor alarm.
February 15, 2000	7:29 p.m. - IP2 declares an ‘Alert’ and operators manually shut down the reactor. The tube leakage rate was approximately 146 gallons per minute (gpm).
February 15, 2000	7:41 p.m. - IP2 notifies state and county authorities and NRC Resident Inspector.
February 15, 2000	8:49 p.m. - NRC enters ‘Standby’ response mode.
February 15, 2000	11:35 p.m. - NRC downgrades response to ‘Monitoring’ mode.
February 16, 2000	2:20 p.m. - The primary plant pressure is reduced below that of the number 24 steam generator to terminate the tube leakage.
February 16, 2000	4:56 p.m. - IP2 achieves cold shut down, meaning the reactor coolant system temperature is below 200 degrees Fahrenheit.
February 16, 2000	7:15 p.m. - NRC exits ‘Monitoring’ mode and returns to normal operation.
February 18, 2000	NRC Region I dispatched an Augmented Inspection Team (AIT) to review the steam generator tube rupture event

BACKGROUND

Function of Steam Generators in PWRs

There are two types of nuclear power plants being used in the United States to produce electricity, the boiling water reactor (BWR) and the pressurized water reactor (PWR). In PWR plants like IP2, water which serves to cool the reactor is contained in the 'primary system.' This water is heated by the nuclear reactor to about 600 degrees Fahrenheit. However, because the water flows through the reactor vessel under very high pressure, it is prevented from boiling. Since this water surrounds the nuclear reactor, it contains radioactive fission products. The superheated water flows from the reactor to the steam generator. Inside the steam generator, the hot water flows through numerous tubes. Uncontaminated water from the 'secondary system,' which is external to the nuclear reactor, enters and flows around the outside of the steam generator tubes and becomes heated. It should be noted that water from the primary system does not normally mix with water from the secondary system. When the secondary system water absorbs sufficient heat, it boils and forms steam. Once steam is formed, it is piped to the main turbine which, in turn, drives an electrical generator resulting in a flow of electricity.

NRC and Industry Concerns Regarding PWR Steam Generator Tube Integrity

In the 1970s, the NRC and the nuclear industry began to identify problems relating to the integrity of the steam generator tubes in PWRs. Tube integrity ensures that the tubes are capable of performing their intended function. The pressurized water inside the steam generator tubes contains radioactive reactor fission products. The concerns raised relative to steam generator tube integrity were centered on the fact that steam generator tube failures could result in radioactive primary system water entering the uncontaminated secondary system water. Such an occurrence could result in a release of contaminated steam to the environment. The NRC and nuclear industry became concerned about steam generator tube integrity because the steam generator tubing was, and continues to be, subject to a variety of corrosion and mechanically induced degradation mechanisms.

Degradation Found in PWR Steam Generator Tubes

In 1975, the NRC was informed by Westinghouse Electric Corporation that several plants which it designed had experienced steam generator tube degradation in the form of a reduction in tube diameter, later termed "tube denting." IP2 was one of the PWR facilities that suffered steam generator tube denting. It was noted at that time that dented tubes were susceptible to stress corrosion cracking.

The NRC and nuclear industry research data revealed that early models of commercial nuclear power plant steam generator tubes were formed from Alloy 600, a corrosion-resistant high-nickel blend. Eight nuclear plants, including IP2, had Westinghouse Model 44 steam generators that used Alloy 600 material for tubing. Most of the steam generator tubes which required repair over

the years have been Alloy 600 tubes. The reason these steam generator tubes have required repairs was corrosive products (typically magnetite and cooper) accumulating in and around the tube and tube support plates. These corrosive products cause tubes to dent, which can result in the tubes developing stress corrosion cracks. IP2 is one plant that had begun accumulating magnetite and copper in its steam generators.

The degradation problems particular to Westinghouse Model 44 steam generators resulted in seven plants replacing their steam generators. IP2 is the only plant with Westinghouse Model 44 steam generators that has not replaced its steam generators. Nuclear power plants with Westinghouse Model 44 steam generators that have replaced their steam generators are:

Plants	Commercial Operation Dates	Replacement Dates
Ginna	07/1970	06/1996
Point Beach 1	12/1970	03/1983
H.B. Robinson	03/1971	10/1984
Point Beach 2	10/1972	12/1996
Turkey Point 3	12/1972	04/1982
Turkey Point 4	09/1973	05/1983
Indian Point 2	**08/1974**	**N/A**
Indian Point 3	08/1976	06/1989

In August 1990, the NRC issued Information Notice (IN) 90-49: "Stress Corrosion Cracking in PWR Steam Generator Tubes" to holders of nuclear power plant operating licenses or those requesting construction permits for PWRs. The information notice was intended to inform licensees of problems involving stress corrosion cracking in PWR steam generator tubes. The IN stated that in light of available technology, reliable detection and sizing of stress corrosion cracking during inservice inspections posed a significant challenge.

Over the years, the NRC and nuclear industry found that the small U-bend regions of the steam generator tubes in particular were exhibiting stress corrosion cracking. In 1997, the NRC, cognizant of the U-bend degradation, issued IN 97-26: "Degradation in Small-Radius U-Bend Regions of Steam Generator Tubes" to all holders of nuclear power plant operating licenses or those requesting construction permits for PWRs. The purpose of IN 97-26 was to disseminate information about degradation which was affecting small-radius (rows 1 and 2) U-bend regions of steam generator tubes and to alert utilities of potential problems associated with ensuring the integrity of the small-radius U-bends. IN 97-26 noted that licensees that used Westinghouse-

designed steam generators had, for many years, identified indications of stress corrosion cracking in the U-bend regions of tubes with small radii. During the late 1970s and early 1980s, many nuclear power plants plugged the small-radius U-bend tubes as a preventive measure to avoid leakage. Further, IN 97-26 advised licensees that the susceptibility to cracking in small-radius U-bends and the findings of recent field inspections emphasized the importance of inspections of this area of steam generators with techniques capable of accurately detecting U-bend degradation.

Maintaining PWR Steam Generator Tube Integrity

The NRC established requirements for steam generator tube integrity. The NRC required that steam generator tubes have an extremely low probability of abnormal leakage and be periodically inspected and tested. The performance of inservice inspections (ISIs) by licensees was and continues to be a critical element in maintaining steam generator tube integrity. The scope and frequency of these inspections vary from plant to plant based on the extent of the degradation. The requirements for inspection frequency and scope are based primarily on experience, engineering judgement, and practicality. The frequency is intended to coincide with refueling outages so that regular inspections will not unnecessarily affect plant availability and cause needless expense. The scope of a typical steam generator tube inspection consists of selecting a representative tube sample for examination. For plants with extensive amounts of degradation, 100 percent of the tubes are inspected at every outage. Individual plants specify in the Technical Specifications portion of their licenses that ISIs are to be performed at periodic intervals. It should be noted that Technical Specifications are part of NRC licenses that dictate the conditions under which a plant can operate. Technical Specifications include safety limits, conditions for operations, surveillance and oversight requirements, design features and administrative controls.

Traditional methods for performing ISIs of steam generators in the 1970s proved inadequate for the reliable detection and sizing of cracks. As a result, the nuclear industry developed improved inservice inspection methods capable of detecting cracks before tube integrity was potentially impaired. However, use of these improved inspection methods varied from plant to plant. In addition, inspection data analysis procedures and data analyst training had, in a number of instances, proven inadequate. The NRC and industry recognized that deficiencies in this area could result in tube flaws being overlooked during the inspection and data evaluation process. As a result, in 1995 the NRC issued Generic Letter (GL), GL95-03 “Circumferential Cracking of Steam Generator Tubes,” that emphasized the importance of performing comprehensive examinations of steam generator tubes using appropriate inspection techniques and equipment capable of reliably detecting steam generator tube degradation.

Steam Generator Tube Rupture at Indian Point Unit 2

In the 25 years since the NRC became aware of steam generator tube degradation, there have been seven PWR steam generator tube ruptures in commercial nuclear power plants, all involving tubes fabricated from Alloy 600. IP2 has had four forced outages caused by tube leaks.

On February 15, 2000, IP2 experienced a rupture in one of its Westinghouse Model 44 steam generator tubes which allowed water from the reactor to leak into the steam generator. The leak of primary system water contaminated the secondary system and resulted in a minor discharge of radioactive steam to the atmosphere.

IP2 has four steam generators that are designated as the numbers 21, 22, 23, and 24. Each steam generator contains 3260 Inconel Alloy 600 tubes. The failed tube was identified as the row 2, column 5 tube, a tight radius U-bend tube, in the number 24 steam generator. Upon visual inspection of the rupture area, the flaw was characterized as a crack, approximately 2 to 3 inches in length. The steam generator tube rupture resulted in a primary system to secondary system leak which discharged approximately 146 gallons of water per minute. As a result, IP2 declared an “Alert”; the second level of emergency action in the NRC required emergency response plan. In compliance with its technical specification, IP2 initiated plant shut down after 13 minutes. The leak was terminated after about 19 hours. During this time, an estimated 19,197 gallons of contaminated primary system water transferred to the secondary system. The radioactive water which was generated as a result of this event was eventually processed (filtered, demineralized and sampled) to reduce the amount of radioactive material to within acceptable regulatory levels. The treated water was then discharged into the Hudson River during several controlled releases. The NRC assessment of radioactive steam releases during the February 15, 2000, incident concluded that the total radioactivity released to the environment was relatively small and within regulatory limits.

DETAILS

I. NRC's Oversight of Events Leading Up to the February 15, 2000, Steam Generator Tube Rupture at IP2

Region I Had Identified Weaknesses at IP2

IP2 is located in Buchanan, New York, and is under the regulatory oversight of NRC's Region I. Region I is responsible for the implementation of the NRC's inspection program at the nuclear facilities within the northeast region of the United States.

The Region has established a three-pronged approach in its oversight of IP2; resident inspector inspections, routine regional inspections and special inspections. According to the Region I management and staff, IP2 has received considerable inspection and management attention over the last few years. One Region I manager noted that "IP2 has been languishing around as a plant that we in the Region have been concerned about for a number of years now . . .".

Through its inspection and oversight efforts, Region I has found that IP2 has been challenged with identifying and correcting problems at the plant. Region I staff and mangers stated that IP2 has had a number of performance issues since the mid-1990s. Specifically, Region I has been concerned with two key areas at IP2: (1) a lack of a robust corrective action program and (2) a lack of a critical self-assessment process. Region I also discovered shortcomings in IP2's emergency preparedness program which were documented in Region I inspection reports. However, the Region has never believed that IP2 was unsafe to operate or warranted being shut down.

NRC Oversight of Steam Generators at IP2

OIG learned that, although historically Region I has provided IP2 with enhanced oversight, the Region did not focus specifically on the plant's steam generators. According to the Region I Administrator, the Region did not view steam generators as significant in the overall oversight and regulation of IP2. During IP2's 1997 refueling outage, Region I conducted a special inspection to assess the effectiveness of IP2's ISI program with particular emphasis on the inspection of the steam generators. Region I's special inspection focused on IP2's use of the steam generator testing procedures and the qualification and certification of personnel conducting the steam generator tube examination. The Region I inspector who conducted this inspection told OIG that this was not a physical inspection of IP2's steam generators but rather a document review of how IP2 conducted its ISI program. This was the last time Region I conducted a review of IP2's steam generator ISI program. This Region I inspector told OIG that more regional oversight of IP2 steam generators could have enhanced the performance of IP2 and possibly prevented the steam generator tube failure in February 2000.

NRC Senior Managers Had Identified Broad Performance Issues at IP2

OIG reviewed the minutes of the May 2000 NRC Senior Management Meeting (SMM) and noted the following commentary by NRC senior management on past performance issues at IP2:

> From late 1998 to the August 1999 event, the plant was on-line for an extended time; however, during that time, NRC inspection findings continued to illustrate corrective action program performance problems, work control problems, and lapses in engineering support. During this same time frame, there was also some buildup of equipment deficiencies and some loss of licensee focus on their improvement plan.

The following excerpt of the minutes described the reasoning behind the past level of oversight provided to IP2 by the NRC senior managers:

> Indian Point 2 was discussed at SMMs between June 1997 and July 1998. At the July 1998 meeting, the senior managers determined that considerations for maintaining agency attention and giving the licensee a period of time to execute its performance improvement initiatives outweighed those for increasing agency attention and that no agency level action was required. The plant was not discussed at the April 1999 SMM.

The following excerpt was commentary on risk significant events at IP2 covering the May 1999 to May 2000 SMM review period:

> The first significant event involved an August 1999 automatic reactor shutdown that was complicated by an electrical transient that adversely affected important safety-related equipment and control annunciators. The electrical transient was caused and aggravated by plant equipment deficiencies and configuration control problems. . . . In February 2000, a second significant event occurred. A steam generator tube failed which resulted in declaration of an Alert.
>
> In both of these events, the senior managers noted concerns that illustrate a number of longstanding performance issues. . . . The senior managers further were concerned with recurrent emergency preparedness weaknesses that have hampered performance during exercises and during the August 1999 and February 2000 events.

IP2 Examination of Steam Generators in 1997

On June 13, 1997, IP2 completed an inservice inspection of the steam generator tubes during the plant's 13th refueling outage. IP2's Technical Specification (TS), 4.13.A.2.a - Extent and Frequency of Examination, requires the licensee to conduct steam generator examinations no less than 12 and no later than 24 calendar months after the previous examination. Under TS 4.13.C.1, IP2 is required to submit its proposed steam generator inspection plan to the NRC at least 60

days prior to each scheduled examination. IP2 is required by TS 4.13.C.2 to submit the results of each steam generator inspection to the NRC within 45 days after the completion of the examination. OIG ascertained that both of these documents were forwarded to the cognizant NRC program office, the Office of Nuclear Reactor Regulation (NRR), within the allotted time.

OIG learned that on June 3, 1997, in a telephone conference call with the staff of NRR, a Region I reactor engineer, and the Region I Branch Chief of Civil Mechanical and Material Engineering, IP2 verbally provided details concerning their ongoing 1997 steam generator examination. During this telephone conference call, IP2 informed the call participants that testing had identified a new degradation mechanism of stress corrosion cracking of the outside diameter of steam generator tubes.

NRC Staff Receive the 1997 Inspection Report from IP2

On July 29, 1997, IP2 submitted the 1997 steam generator inspection report to the NRC. The report stated that the examination included a 100 percent inspection of the U-bends of rows 2 and 3 in steam generators 21, 22, 23, and 24. The examination was conducted using either a Cecco-5 or a Plus Point probe, to the extent possible, and a rotating pancake coil probe to examine the tube U-bends if the narrow radii of the bends precluded passage of the other probes. The inspection report concluded that the 1997 steam generator tube inservice examination demonstrated that the IP2 steam generators were acceptable for continued service at full power.

OIG was told that plant licensing actions, such as amendment requests, are coordinated through a Project Manager in the Division of Licensing and Project Management Directorate (DLPM) of NRR who is assigned responsibility for specific plants. The assigned Project Manager acts the point of contact for the nuclear power plant on any licensing action and is responsible for ensuring that required technical reviews are forwarded to the Materials and Chemical Engineering Branch (EMCB), which is the branch responsible for assessing the technical adequacy of licensee inspections and preparing safety evaluation reports. The Project Manager is also responsible for ensuring that staff technical questions submitted to a licensee in the form of a request for additional information (RAI) are appropriate and not burdensome on the licensee.

OIG learned that neither the Region I nor NRR staff conducted a technical review of IP2's 1997 steam generator tube inservice inspection report when it was submitted in July 1997. The Project Manager assigned to IP2 from 1996 to 2000, told OIG that steam generators are outside of his area of expertise. He stated he had only an elementary understanding of nondestructive examination methods; consequently, he conducted what amounted to a cursory review of IP2's 1997 steam generator inspection results. The Project Manager told OIG that he assumed the EMCB technical staff, who also received a copy of the steam generator inspection results, reviewed the report and were satisfied with the data. The Project Manager said that, although the NRC has technical staff with expertise to conduct a technical review of steam generator inspection reports and NRR often consults with a technical contractor to assist in the review, the staff does not spend a great deal of time reviewing the inspection results. The Project Manager commented that the staff relies on the industry and the licensees to evaluate the steam generator

inspection data. The Project Manager felt that the NRC lacked the manpower and resources to conduct a comprehensive review of the steam generator inspection data and, even if the NRC had the assets, such a review would not have prevented the tube rupture. The Project Manager told OIG that licensees contract for their steam generator inspections, and IP2 contracted with Westinghouse, the manufacturer of IP2 steam generators, to perform their inspections.

OIG reviewed the Project Managers Handbook which delineates the role and duties of an NRR Project Manager. Section 5.1 of the Project Managers Handbook discusses the various processes the Project Manager uses to evaluate the performance of a licensee, to include reviewing inspection reports and consulting with the technical review branch as necessary.

The staff of the Division of Reactor Projects, Region 1, as well as both staff and management of EMCB, NRR, explained to OIG that NRC requirements do not direct the staff to review steam generator inspection reports for quality or sufficiency. The Section Chief, EMCB, told OIG that the licensees are required to submit the inspection results, but there is no requirement for the NRC staff to review the inspection report and they are not typically reviewed. The Section Chief said that inspection reports are considered "historical information" and are retained by the staff in the event questions arise. The Director of the Division of Engineering, NRR, told OIG that although not all inspection results are reviewed, reports which are deemed important do receive staff attention.

The Director of NRR told OIG that there is a need to verify information submitted by the licensee and to provide independent reviews. He said that NRR Project Managers coordinate the review of the inspection results and arrange technical staff support. The Director said that the review is dependent on the expertise of the Project Manager, and the Project Manager determines what input is needed to write a safety evaluation report. The Director commented that technical contractors may be hired for independent data reviews, and, as necessary, NRR can engage the Office of Nuclear Regulatory Research (RES) for their expertise. The Director said that the NRC looks to the Project Managers to be aware, in a general sense, of what is happening at the nuclear power plant over which they have oversight. He said that the NRC regions no longer have the expertise to look at steam generators and they defer to the program office at NRC headquarters to provide technical oversight. The Director of NRR told OIG that NRR staff review of steam generator inspections varies from plant to plant based on technical specifications requirements, staff sensitivity to the condition of the plant's steam generators, staff availability, and work load.

OIG noted that in July 1997, the same month that the IP2 steam generator inspection report was received by NRR, the NRC Office of Public Affairs issued "NRC Technical Issues Papers and Fact Sheets: Steam Generator Tube Issues." This paper summarized the safety role of steam generator tubes, tube degradation, tube repair criteria and inspection issues. The 1997 Technical Issues Papers and Fact Sheet stated the following about the safety role of steam generator tubes:

> These [steam generator] tubes play an important safety role because they stand between the radioactive and nonnuclear sides of the plant. The integrity of the tubing is instrumental in minimizing leakage of water between the two sides.

> There is the potential that if reactor fuel is damaged and several tubes were to burst at once, it could lead to a fairly significant release of radioactive steam.

The 1997 Technical Issues Papers and Fact Sheet also stated the following relative to the critical nature of steam generator tube inspections:

> The performance of inservice inspections is a critical element in maintaining steam generator tube integrity. The scope and frequency of these inspections vary from plant to plant based on the extent of the degradation. For plants with extensive amounts of degradation, 100% of the tubes are inspected at every outage.
>
> . . .In addition, inspection data analysis procedures and data analyst training have, in a number of instances, proven inadequate. This has the potential for significant tubing flaws to be missed. As a result, the staff issued a generic letter (Generic Letter 95-03 "Circumferential Cracking of Steam Generator Tubes") that emphasizes the importance of performing comprehensive examinations of steam generator tubes using appropriate inspection techniques and equipment capable of reliably detecting steam generator tube degradation.

This 1997 Technical Issues Papers and Fact Sheet document was revised in September 1999 and is now available as "TIP: 27-Steam Generator Tube Issues."

NRC Staff Reviews a 1999 License Amendment Request from IP2

On December 1, 1998, IP2 submitted to the NRC a one-time extension of the steam generator inspection interval from June 3, 1999, to June 3, 2000, thus modifying the TS 4.13.A.2.a requirement of conducting this inspection no later than 24 calendar months after the previous examination. The license amendment number 201 would allow the steam generator inspection interval to coincide with the year 2000 refueling outage (IP2's 14^{th} refueling outage). The amendment request also proposed the removal of the requirement that IP2 receive NRC concurrence on their planned steam generator examination program as outlined in TS 4.13.C.1.

In a letter to the NRC, IP2 said that an inspection of the steam generator tubes was completed on June 13, 1997, during the last refueling outage. As support for the request for deferment of the 24-month steam generator examination interval, IP2 noted there would be 304 days of nonoperation between the last steam generator inspection in 1997 and the scheduled inspection in 1999. IP2 explained that following the completion of the 1997 inspection, the plant returned to service only to be shutdown on October 25, 1997, for an unscheduled maintenance outage. IP2 remained in cold shutdown condition for 304 days and was restarted on August 5, 1998. An additional five days in cold shutdown was anticipated as a result of the planned mid-cycle outage to perform periodic refueling cycle tests. IP2 asserted that a total of 309 days in cold shutdown should permit extending the current inspection interval to April 16, 2000. An additional 48-day extension on the steam generator inspection was requested by IP2 to coincide with the refueling

outage scheduled for June 3, 2000.

The IP2 letter requesting the additional extension reported that extending the steam generator "operating" duration by 48 days would not significantly increase wear which might lead to tube failure. IP2 believed because the steam generators were maintained in cold shutdown temperature conditions for 304 days, the environment for tube corrosion was reduced to an inconsequential level. IP2 believed that there would not be any appreciable steam generator tube wear or degradation as a result of this extension. As a result, IP2 stated it had a high level of confidence that corrosion growth and new corrosion initiation during the cold shutdown were essentially nonexistent, and the steam generators were prepared to operate for a full fuel cycle without incident.

OIG learned that IP2's license amendment request was staffed through DLPM. The Project Manager for IP2, responsible for the appropriate disposition of the license amendment request, told OIG he reviewed the license amendment request to determine the action being requested by IP2, and he sent the amendment request to EMCB for a technical review and safety evaluation. The Project Manager told OIG that if EMCB required additional information from IP2 to complete the safety evaluation and needed to prepare an RAI, he would coordinate a conference call between the EMCB technical reviewers, IP2, and himself. The purpose of the conference call would be to provide the plant advance notice of the pending questions and to discuss any issues which may require verbal clarification. The Project Manager told OIG that before the staff submitted the RAI to IP2 for amendment number 201, several meetings were held with the EMCB senior and junior technical reviewers to discuss IP2's intended use of a new eddy current probe. The Project Manager told OIG that there was also a conference call between the staff and IP2 to discuss EMCB staff's reasoning behind the RAI. The Project Manager said that after IP2's amendment request was forwarded to EMCB, he had little involvement in the amendment review process.

The Project Manager told OIG that at the time of IP2's submission of license amendment request number 201, the staff had no reason to question IP2's steam generator tube integrity or degradation mechanisms because past inspections by IP2 did not yield results which were out of the ordinary. According to the Project Manager, IP2's submission of amendment request number 201 was a routine matter.

The EMCB Chief told OIG that once the license amendment request was received in EMCB, it was assigned to a staff member for a safety evaluation and review. He informed OIG that all technical reviews relating to steam generator matters were ultimately conducted under the supervision of a senior staff engineer, thus relieving the Branch Chief of such responsibilities. IP2's license amendment request was assigned to a junior materials engineer in EMCB to review and prepare a safety evaluation report. The EMCB Chief believed that the review of the request for an inspection interval extension was an appropriate task for the junior engineer because it was not a complicated assignment.

The EMCB junior engineer tasked with reviewing the license amendment request told OIG that

she sought assistance from the EMCB senior engineer. The EMCB junior engineer acknowledged being inexperienced in conducting reviews of license amendment requests regarding steam generators. The junior engineer stated that she reviewed several documents in an effort to evaluate the merits of IP2's proposed amendment. The junior engineer specifically recalled reviewing two documents - Generic Letter (GL) 91-04, which pertained to the periodic inspection intervals required for PWR licensees and IP2's 1997 steam generator inservice inspection report. Based on the junior engineer's evaluation of the licensee's amendment proposal, the aforementioned documents, and advice from the senior engineer, she felt some issues remained unclear. The junior engineer, with the assistance of the senior engineer, prepared questions for the licensee in the form of an RAI.

OIG learned that the RAI sent to IP2 on May 5, 1999, asked four questions. The junior engineer stated that the RAI requested IP2 to explain its methodology, techniques and assessment for ensuring adequate structural integrity for the full fuel cycle. The junior engineer added that she had concerns regarding the steam generators crack growth rates that were not addressed in the original license amendment submittal. IP2 responded to the RAI on May 12, 1999. The junior engineer believed that although IP2's response to the RAI was adequate, she said that "It may have been a little weak . . . " OIG learned that the junior engineer did not ask additional questions of the licensee, although she believed the responses to the RAI could have been more robust. The junior engineer stated that a second request of questions was "frowned upon" by NRR management. She recalled a 1999 staff meeting in which the NRR was told they should attempt to issue only one round of RAIs to licensees. The junior engineer stated that "I felt like we were stuck" with the IP2 responses to the RAI.

OIG reviewed NRR Office Letter No. 803, "License Amendment Review Procedures," which established procedures for processing license amendments for plants with an operating license. Section 4.3 of the NRR Office Letter, states that "When an RAI is necessary, the staff should make every effort to limit itself to one round of RAIs per TB [Technical Branch] for an amendment application. The established timeliness goals are likely to be exceeded if multiple RAIs are needed to complete the staff's review of a license amendment application."

The junior engineer stated that although IP2's answers to the RAI were not as complete as she would have liked, she reviewed IP2's 1997 steam generator inspection report to enhance her understanding of the issues in question. Based on her review, she was able to prepare a safety evaluation report granting technical approval of the steam generator inspection deferment. The junior engineer stated that she prepared a draft safety evaluation report and submitted it to the senior engineer for review.

The EMCB senior engineer told OIG that he has been involved with steam generators throughout his 21-year career with the NRC and is considered the lead steam generator engineer within EMCB. He said that he assisted the junior engineer in preparation of the RAI to ensure the questions were adequate. The senior engineer informed OIG that he did not review the RAI response from IP2, and he did not review any documentation used by the junior engineer to prepare the RAI or safety evaluation report (SER). The senior engineer said that he did not necessarily believe that the safety significance of the extension request warranted a review of the 1997 IP2 inspection results. The senior engineer said he concurred with the safety evaluation report prepared by the junior engineer. He said, "I really didn't consider this to be one of our more risk significant issues. Therefore, the level of priority I was giving this in terms of my level of attention, was relatively low." The EMCB Chief who had final signatory authority for the safety evaluation report, told OIG he concurred with the findings based on the presumed review and approval by the senior engineer. The EMCB Chief told OIG that he presumed that both the junior and senior engineer would have considered the degradation history associated with IP2's steam generator tubes and the examination methods used in the inspection process during their safety evaluation review.

In the SER, dated June 9, 1999, NRR reports the following:

> 5.0 SUMMARY - Based on the above evaluation, the staff finds that conducting TS 4.13A.2.a during a mid-cycle surveillance in June 1999 to be unnecessary. NRC staff concludes that the licensee's proposal to allow a one time extension to the steam generator tube inspection interval is acceptable and that there is reasonable assurance that steam generator tubes will maintain structural and leakage integrity for the entire cycle 14 operation. The staff also finds that since the licensee is required to submit their proposed steam generator examination program 60 days prior to the scheduled outage, receiving formal NRC concurrence is not necessary.

The Project Manager for IP2 told OIG that he reviewed the response to the RAI, but he relied on the technical staff to attest to the sufficiency of IP2's reply in using the information to draft the safety evaluation report.

NRC Reviews Conducted Following the February 15, 2000 Event

Soon after the February 15, 2000, event at IP2, NRR requested that the Office of Regulatory Research (RES) perform an independent technical review of the safety evaluation report prepared by the NRR staff in support of the steam generator tube inspection extension granted in June 1999. At the conclusion of this review, the RES Director stated that his staff looked at all available information to determine if IP2 had conducted a reasonable assessment of their steam generators and if the NRR staff had completed a reasonable evaluation of the information provided by IP2. The RES Director informed OIG that the RES review was assigned to a senior

metallurgical engineer in the Materials Engineering Branch (MEB) who was considered an expert on steam generator tube integrity issues.

RES responded to NRR in a memorandum dated March 16, 2000. RES reported to NRR that it could not reconcile several statements and conclusions in the safety evaluation report prepared by NRR with the information NRR received from the licensee. Among other findings, the RES memorandum stated that IP2's assessment of two forms of degradation found in their steam generators was inadequate: (1) outside diameter stress corrosion cracking (ODSCC) above the top of the tube sheet locations; and, (2) primary water stress corrosion cracking (PWSCC) at a Row 2 U-bend. OIG learned that RES considered this to be in conflict with statements made in the safety evaluation report which concluded that the tubes would meet structural and leakage integrity through the end of the operating cycle.

The RES reviewer told OIG that his primary concerns with the safety evaluation report were based on IP2's answers to the RAI and the information in the IP2 1997 steam generator inspection. The RES reviewer said that IP2 did not offer a satisfactory argument for some of the degradation mechanisms that were present in their generators. Further, he commented that IP2 did a very poor job of conducting their steam generator tube operational assessment. The RES reviewer told OIG that based on information that he reviewed, the analysis completed by IP2 was very simple. As an example, he cited the case of the U-bend cracking that eventually caused the failure on February 15, 2000. The RES reviewer believed that IP2's crack growth rate analysis was faulty. The reviewer told OIG that he was surprised that this faulty analysis was accepted by the NRR staff. The reviewer noted that in their operational assessment, IP2 said that this was the first time that they detected this type of crack in the U-bend, that the crack was small, and that it had taken 23 years to develop this crack. For these reasons IP2 concluded that the growth rate would be minimal.

OIG interviewed an NRC contractor who was tasked by the NRC to review the cause of the February 15, 2000, steam generator tube failure at IP2. The contractor has been employed by the NRC, specifically by NRR, since the late 1970s, and he is considered a leading expert in the eddy-current testing and data evaluation procedures which are used to inspect and assess viability of PWR steam generator tubes. In addition to assisting in the evaluation of the cause of the February 15, 2000, steam generator tube failure at IP2, the NRC contractor reviewed IP2's 1997 steam generator inspection data. The NRC contractor informed OIG that the cause of the February 15, 2000, tube failure was a flaw that was indicated but missed during the 1997 IP2 inspection of the U-bend of row 2, column 5 in steam generator 24. The NRC contractor said that the 1997 IP2 steam generator inspection was conducted using probes and procedures designed to detect outer diameter defects, rather than the inner diameter defects that are present in the U-bends. The NRC contractor commented that other factors which contributed to the tube defect being missed during the 1997 inspection included poor eddy current analyst performance and inferior, ambiguous, eddy current guidelines in use at the time.

The NRC contractor told OIG that his recent review of IP2's 1997 steam generator inspection results revealed that approximately eight defects were indicated but missed. The contractor stated,

> . . . the licensee had not found all of the defects that were present in 1997. In fact, they missed the vast majority of them in their inspection. I think that if they had done a good inspection, they would have--namely, with a high frequency probe, they would have caught this.

The NRC contractor informed OIG that IP2 found one inner diameter defect in steam generator 24 U-bend, Row 2, Column 67, during the 1997 steam generator examination. The NRC contractor concluded that the detection of this defect in the U-bend region of the steam generator tube should have alerted IP2 to inspect the U-bend area of tubes for more defects. The NRC contractor said the U-bend region is very hard to inspect and is even more difficult at IP2 because the IP2 steam generators have a great deal of copper and magnetite on the outside surface of the tubes that are causing problems in the U-bends. Additionally, the NRC contractor said that IP2 has relatively old steam generators which make them more susceptible to a tube rupture. The NRC contractor told OIG that the inner diameter defect in the U-bend region found during the 1997 inspection, the age of the IP2 steam generators, and the copper and magnetite deposits, should have been sufficient warning of a possible steam generator tube rupture.

The NRC contractor told OIG that use of a smaller, high frequency eddy current probe eliminates signal interference caused by copper and magnetite deposits. In reprofiling the 1997 IP2 eddy current data of the tube that ruptured on February 15, 2000, using two different frequencies, the NRC contractor was able to ascertain that the depth of the crack was “100 percent through-wall in several places.”

The NRC contractor told OIG that a high frequency probe had been used in the past at Kewaunee Nuclear Power Plant and at Maine Yankee Nuclear Power Plant in 1995; however, Westinghouse, the contractor responsible for conducting IP2's steam generator inspections, resisted using such a probe.

OIG reviewed the April 14, 2000, report, “Root Cause Evaluation for Steam Generator Tube Rupture Event of February 15, 2000,” prepared by IP2 which summarized the mechanisms by which the leakage occurred and summarized the technical investigation of the primary system to secondary system leakage event. This document reported that, following the February 15, 2000, rupture of the row 2, column 5 steam generator tube, IP2 re-analyzed the1997 inspection data for this tube. IP2 found that at the time the data was collected the flaw in the tube “had an average depth of 63-71% and a maximum depth of 92%.”

An NRC inspector who was a member of the NRC Augmented Inspection Team (AIT) that was conducted as a result of the February 15, 2000, tube failure, made comments to OIG similar to those of the NRC contractor regarding IP2's 1997 steam generator inspection. He said, “I think there were some problems with the inspection they conducted in [19]97, particularly with the

quality of the eddy-current data they were collecting." According to the AIT member, contractor personnel hired by the licensee to perform IP2's past steam generator inspections recognized, in hindsight, that the 1997 data, in particular inspection of the tube that failed, was not sufficient.

A RES senior metallurgical engineer assigned to review the IP2 steam generator issue, told OIG that he believed that the NRC missed opportunities to gain insight into the extent of the steam generator degradation at IP2. He said the first opportunity came as IP2 was conducting their steam generator tube inservice inspection in 1997. The RES senior metallurgical engineer said that the NRC could have provided more oversight of the licensee as they conducted their eddy-current probing of the steam generators. He continued by saying that another opportunity came when the licensee submitted its 1997 steam generator inspection. The RES engineer said that the NRC staff should have reviewed the inspection report. He said that if the NRC staff had conducted a detailed review of the 1997 steam generator inspection results, they might have recognized indicators of the tube that ruptured in February 2000. The RES engineer commented that yet another opportunity came during the 1999 review of the IP2 request for extending the steam generator inspection interval. The RES engineer told OIG that the NRC had asked the right questions; however, the answers were not very good.

Another NRC inspector assigned to the AIT responsible for review of the steam generators made similar comments to OIG regarding the indicators which surfaced during the 1997 IP2 steam generator inspection. The AIT member agreed with the RES engineer that IP2's operational assessment conducted in 1997 was not especially vigorous. He also believed the quality of data collected by IP2 was not very robust, and IP2 missed a defect which indicated a possible tube failure. He added that NRR should have been more questioning of the 1997 steam generator inspection. He commented that the NRC should be more vigilant and intrusive in the steam generator inspection processes, especially with plants such as IP2 that are operating with old generators.

NRC is Aware of the Steam Generator Leakage at IP2 during 1999

OIG discovered that the NRC was aware of some leakage of the IP2 steam generators on three different occasions since the summer of 1999. The AIT manager said that during the AIT inspection it was discovered that IP2 operators noticed marginal leakage in either June or July 1999, which they felt was possibly coming from steam generator number 24. Later in October 1999 while the plant was shut down, one of the NRC resident inspectors at IP2 told OIG that he recalled being advised by IP2 operators that they were tracking and trending a small amount of leakage; however, he related that IP2 operators were unable to obtain positive confirmation that the leak was in steam generator number 24. The Resident Inspector stated that the NRC oversight practice under these circumstances is to provide guidance and ensure the licensee monitors any changes in the situation. This was what they instructed IP2 operators to do.

The April 14, 2000, "Root Cause Evaluation for Steam Generator Tube Rupture Event of February 15, 2000," prepared by IP2, contains a leak rate history chart covering the period of January 1, 1999, through February 11, 2000. OIG reviewed the chart which revealed that during this period of time there were several days in January without reported leakage and a period of approximately a month and a half during September and October with no data recorded on the chart. The greatest leakage was approximately 4.5 gpd and was reported to have occurred during the period from October 22, 1999 to November 5, 1999.

The NRC Project Manager acknowledged to OIG that the steam generator leakage had been tracked by IP2 in the September/October 1999 time frame, but he said that at the time he was unaware of the leakage. The Project Manager told OIG that until several years ago, he participated in the 7:30 a.m. daily conference call between the Region and the Resident Inspectors at IP2. He said that for personal reasons he changed his work schedule to begin his work day at 7:45 a.m. The Project Manager told OIG that because of his revised work schedule, he was unable to participate in the 7:30 a.m. daily conference call. The Project Manager said that the leakage being monitored by IP2 could have been discussed during one of the conference calls that he missed. He said that he relied on the Region and resident inspectors to notify him in the event of a significant issue but that the level of leakage at that time had not warranted such notification.

OIG reviewed the Project Manager's handbook which describes the role of the Project Manager as "the focal point of information for the plant and is the only person who has a view of the total aspects of the plant." Having comprehensive knowledge of past and present plant issues, the Project Manager is expected to use this knowledge base to focus on the early identification of problem areas. The handbook outlines the degree of familiarity and contact the Project Manager is expected to have of those components within the NRC, as well as those technical and specialized resources outside of the NRC, which would impact on the efficiency with which the NRC fulfills its regulatory mission.

The IP2 Resident Inspector informed OIG that there was significant change in the leakage in early February 2000. On February 6, 2000, the nitrogen-16 monitor which tracks leakage from the primary system to the secondary system, indicated a leak rate of approximately 1.5 gallons per day (gpd). The Resident Inspector stated that this information was provided to Region I management for additional review and guidance. Region I instructed the resident inspectors to initiate discussions with IP2 operators to confirm their planned course of action should the leak exceed 10 gpd. OIG ascertained that IP2's technical specifications leakage limit was 432 gpd.

The Resident Inspector stated that neither he nor Region I were overly engaged with IP2 regarding the small leak in the steam generators. He stated that there was not an inordinate amount of concern over the leakage because it was well below the technical specification limit of 432 gpd. The Resident Inspector acknowledged that he did not seek additional information regarding the condition of the steam generators, such as the extent of degradation.

II. NRC Oversight of IP2 Emergency Preparedness

Background

At each NRC-licenced nuclear power plant there are on-site and off-site emergency plans to assure that adequate measures are taken to protect the public in the event of a radiological emergency. Federal oversight of emergency planning for nuclear power plants is shared by the NRC and the Federal Emergency Management Agency (FEMA) through a memorandum of understanding. The memorandum is responsive to a Presidential Directive codified as 44 Code of Federal Regulations (CFR) Parts 350, 351, and 352, which mandates that FEMA will take the lead in off-site emergency planning and response and that the NRC will assist FEMA in carrying out this role. The NRC retains ultimate statutory responsibility for the radiological health and safety of the public and the types of activities that the NRC coordinates and is accountable for during an emergency at a licensed facility can be found in NUREG/BR-0123: "RCM-96, Response Coordination Manual."

Each nuclear power plant exercises its on-site emergency plan annually. In addition, each plant conducts biennial coordinated exercises with off-site state and local governmental authorities within the plume exposure pathway emergency planning zone (EPZ) to help ensure that off-site emergency plans function properly. For planning purposes, the Commission has defined a plume exposure pathway EPZ consisting of an area about 10 miles in radius and an ingestion pathway EPZ about 50 miles in radius around each nuclear power plant. EPZ size and configuration may vary in relation to local emergency response needs and capabilities as affected by such conditions as demography, topography, land characteristics, access routes, and jurisdictional boundaries.

The IP2 site is geographically located on the east bank of the Hudson River approximately 24 miles north of New York City (Bronx) boundary line, at Indian Point, Village of Buchanan, Town of Cortlandt in northwestern Westchester County. The site is approximately 2.5 miles southwest of the city of Peekskill, NY. IP2's 10 mile EPZ impacts portions of Westchester, Rockland, Putnam and Orange counties. Each county has its own emergency operations center (EOC) which coordinates their emergency response activities with the State Emergency Management Office (SEMO), State of New York.

NRC Had Longstanding Concerns With IP2 On-Site Emergency Preparedness

OIG learned that since 1998, NRC inspectors at Region I have identified deficiencies related to the emergency preparedness program at IP2. For example, in June 1998, the NRC inspected the emergency preparedness program at IP2 and evaluated its performance during a full-participation exercise. While NRC determined that the emergency preparedness program was adequate, a number of procedural discrepancies were noted. One problem identified by inspectors during this evaluation had been previously identified during an exercise in 1994. As a result of the1998 inspection, IP2 began to implement corrective actions.

Region I emergency preparedness inspectors told OIG that in September 1999, Region I led an

emergency preparedness exercise inspection at IP2 to verify the adequacy of corrective actions taken in response to the 1998 full-participation exercise. During the inspection, Region I inspectors identified six training and communication deficiencies related to the plant's Technical Support Center and Operations Support Center that had been identified during earlier NRC-evaluated exercises. As NRC stated in its inspection report, these findings indicated IP2's overall inability to detect and correct problems and identify their root causes. NRC inspectors also noted there was an apparent ineffectiveness in the emergency preparedness training process and weak oversight of the emergency preparedness program. As a result of the inspection, NRC determined that two, Severity Level IV (non-cited) violations occurred. One NRC inspector told OIG that IP2 performed poorly during the September 1999 drill even after having practiced the drill several times prior to the inspection and knowing that an NRC inspector would be on-site. The inspector noted to OIG that it did not appear that IP2 had "a commitment to excellence," and that the plant did only "enough to get by."

As a result of NRC's inspection findings, IP2 committed to the NRC to implement corrective actions and to conduct another exercise for the NRC evaluation in June 2000. In early February 2000, the NRC staff discussed the emergency preparedness program with IP2. During that discussion, IP2 informed NRC that it had scheduled its follow-up exercise for March 2000.

Approximately two weeks later, on February 15, 2000, IP2 experienced a steam generator tube rupture. During the AIT inspection conducted immediately after the event, numerous problems associated with IP2's on-site emergency preparedness were again evident.

OIG's review of the AIT report revealed that Region I made three preliminary inspection findings of low to moderate safety significance based on the results of the inspection. These programmatic deficiencies were initially identified by the AIT as (1) an untimely augmentation by the emergency response organization, (2) an untimely accountability of on-site radiation emergency workers, and (3) inconsistent dissemination of information to the media and a local official during the course of the event. These findings were also determined to be apparent violations of NRC requirements because IP2 failed to meet NRC emergency planning standards (10CFR 50.47). NRC identified six additional emergency preparedness findings involving failures to implement regulatory requirements. However, because the findings had been entered into IP2's corrective action program and were considered to be of very low safety significance the violations were not cited.

At the May 2000, Senior Management Meeting (SMM), IP2 emergency preparedness performance issues were discussed as reflected in the following excerpt from the minutes of the SMM:

Repeat problems in the area of emergency preparedness (EP) were identified

during the August event and a subsequent exercise. These problems had also been observed during previous inspections and exercises. These observations reflected continued difficulty with implementation of the corrective action program.

NRC Inspectors File Differing Professional View (DPV) Paper Due to On-Site Emergency Preparedness Concerns

On March 30, 2000, two emergency preparedness inspectors from Region I filed a DPV with Region I management due to continuing questions about the readiness of IP2's emergency preparedness program. By way of background, the DPV process is the vehicle within the NRC by which staff can submit their professional viewpoint on virtually all matters pertaining to the NRC's mission. In their draft DPV submission, the filers expressed concern that NRC would authorize the plant to restart following the February 15, 2000, event prior to conducting an exercise to demonstrate that its emergency preparedness program functioned satisfactorily. They noted that while IP2 committed to conducting the exercise by June 2000, they were concerned that IP2 would be permitted to restart prior to that time. One of the DPV filers stressed that an exercise is the only performance-based way to inspect emergency preparedness.

The staff who filed the DPV told OIG that they eventually withdrew their DPV. They stated that Region I senior management, particularly the Regional Administrator, were helpful in addressing their concerns. They stated that during discussions with IP2 officials, Region I management stressed the importance of having a functional emergency preparedness program. At a meeting at Region I on April 26, 2000, IP2 committed to conducting an on-site exercise prior to restart.

An NRC team conducted a follow-up safety inspection from May 15 through June 2, 2000, at IP2 and focused on the on-site emergency preparedness exercise conducted on June 1, 2000. The inspection also included a complete review of the IP2 emergency preparedness program. NRC found that the short-term corrective actions taken in response to the problems highlighted during the February event were adequate. While IP2 continued to exhibit some weaknesses in the Joint News Center activities, the IP2 emergency response organization demonstrated its ability to implement the on-site emergency plan during the June 1, 2000, exercise.

NRC inspectors told OIG that the inspection revealed no "show-stopping" issues at IP2 related to emergency preparedness. However they noted that while the plant showed overall improvement, the inspection also identified existing chronic problems with the plant's emergency preparedness program which made it "obvious that they [IP2] had a long way to go."

On-Site Emergency Preparedness Problems Impact Off-Site Emergency Preparedness

OIG discovered that IP2's on-site emergency preparedness problems impacted the off-site emergency preparedness process. Emergency Operations Center (EOC) representatives from the four counties surrounding IP2 told OIG that the initial information provided by IP2 concerning the February 2000 incident was inaccurate. One of the EOC officials characterized his attempt to obtain information from IP2 as "frustrating." Many of the EOC officials told OIG that on

February 15, 2000, they were notified that an Alert had been declared at IP2. At that time, IP2 reported that a steam generator tube had leaked and no radioactive material had escaped into the environment. The EOC staff and centers were activated and they executed their plans based upon the information they had received.

OIG was told that several hours into the Alert, EOC staff and emergency response personnel, such as police, fire and rescue, learned that there was a release of radioactive materials from IP2. Several EOC officials and command level emergency responders told OIG that they had learned of the release from a media report issued by an IP2 spokesperson. Reportedly, the IP2 representative told the media that a release had occurred but it was below the plant technical specifications.

Although the radioactive release was reportedly below technical specifications, many of the EOC staff and emergency responders realized the significance of any release. These individuals told OIG that their primary concerns were to provide the public with the correct information and to ensure their safety. They also expressed concern that the changing information provided by IP2 relative to the existence or extent of a leak had damaged the public's trust in the EOCs and hurt the capabilities of the first responders to deliver the appropriate services in an emergency situation. Many of the public officials questioned whether they could rely on IP2 as a credible source of information.

Several of the EOC officials and emergency responders explained to OIG that they were placed in an awkward position because of the inaccurate information IP2 disseminated to the public. They also felt that this inaccurate information could have affected the EOC's ability to engage their contingency plans. In one EOC official's opinion, IP2's intent was to time the release of information to avoid the late evening news.

OIG was told of an incident where inconsistent information was disseminated. A command level first responder told OIG that once he learned that an alert had been declared, which was several hours into the incident, he had a member of his command respond to IP2 to ascertain the nature of the alert. At that time, IP2 representatives reported to this subordinate that a leak had not occurred. Later, IP2 staff recanted that information and reported that a small leak had occurred in a steam generator tube. This off-site official told OIG that he was subsequently told by IP2 staff that it was a large leak. This episode has caused him to question the credibility of IP2.

To address this issue, EOC representatives told OIG that they are presently engaged with IP2 to enhance the flow of information between the parties. They also noted that IP2 has been receptive to the use of technology to assist in this endeavor, such as video-teleconferencing between all parties.

IP2 Environs Reportedly Require Immediate Emergency Assessment and Consistent and Timely Notification Processes

Many of the EOC and first responders described IP2's EPZ as one of the most unique in the country. It was described to OIG as a densely populated zone with more than 280,000 inhabitants. OIG discovered that the private residences of President and Mrs. Clinton and the Governor of New York are within close proximity of the EPZ.

Several first responders expressed concerns to OIG that due to population density and the road conditions in the area, any failure to maintain the integrity of the evacuation routes would bring the "plan" to a complete stop. Additionally, within the certain sections of the EPZ there was a growing segment of the population where English is spoken as a second language. These concerns among others caused many of the officials interviewed to comment that it was critical that IP2 make immediate and accurate notifications to the appropriate off-site authorities in the event of an emergency at IP2. These officials considered this type of notification to be paramount in maintaining the public's safety.

All of the EOC officials told OIG that the IP2 technical representatives (TR) tasked to respond to the EOCs on February 15, 2000, to provide technical expertise were delayed as much as two hours in arriving at the EOCs. Several EOC officials explained that during the early stages of the Alert, the TR's expertise was needed to interpret the data coming from the plant. OIG learned that during this absence, one EOC utilized the services of a volunteer firefighter with professional experience in the nuclear power industry to interpret the incoming information. This individual's assessment aided that EOC in its decision making process. OIG was told that at the time of the event, the TR's tasked to respond to the EOC's were not members of IP2's emergency response plan; however, they are now being incorporated into the process.

Certain EOC officials, command level emergency responders, and public officials told OIG that they have learned that IP2 had known for several days that a steam generator tube was leaking. Understanding that the nature of the leak did not require IP2 to notify the EOC's, many officials told OIG that historically IP2 has notified them on less significant events, but in this event neither the officials interviewed nor their staff had been notified of a possible event.

A command level emergency responder also provided a noteworthy example of IP2's inconsistent notification process. This official told OIG that direct telephone communications capabilities exist between IP2 and his office. The circuit is tested daily and has been used in the past to advise his command of less significant events. However, on February 15, 2000, and following another event at IP2 which occurred in August 1999, IP2 personnel did not notify his office. These inconsistencies have caused this official and other area emergency responders to question IP2's credibility and performance. One emergency responder commented that he was confident that the EOCs would notify his agency in a timely manner, but he was concerned that the EOCs would not receive timely notification from IP2.

OIG also determined that during the February 15, 2000, event at IP2, the United States Secret Service personnel assigned to President Clinton's private residence were not advised.

A command level first responder summarized to OIG the need for accurate and expedient

notifications to the EOCs and the first responders by stating that this information is integral to their ability to assess the situation and implement certain actions to protect the public's safety. The responder noted that any delay would drastically impact the emergency preparedness and would have an adverse effect on the public's safety.

OIG reviewed NUREG/BR-0123: "RCM-96, Response Coordination Manual which outlines the responsibility for the radiological health and safety of the public and the types of activities that the NRC is accountable for during an emergency at a licensed facility.

NUREG/BR-0123 delineates the responsibilities of the NRC during a radiological accident with emphasis on providing support to state and local officials and coordinating functions with federal agencies. The following excerpt applies to the NRC's actions during the "Monitoring Phase of Normal Mode" and during the "Standby" mode:

> Monitoring Phase of Normal Mode: The situation may be complex but well understood with no likely safety consequences projected given existing conditions. The region remains in charge, staffing a small team in its Incident Response Center. Headquarters would provide some assistance and support. State and local officials would be notified.
>
> Standby: This situation is sufficiently complex or uncertain to require additional monitoring and preparations to increase the NRC response quickly should it prove necessary. The NRC Operations Center at headquarters will fully staff and direct the NRC response activities. The regional office will initiate the necessary preparations to send a team to the site. Other Federal organizations are notified but are not directly involved. State and local authorities are notified by NRC. They will have been notified by the licensee and may call the NRC for interpretation of the event and response.

Off-Site Perceptions of IP2's Emergency Preparedness

Several EOC officials and first responders told OIG that there is a perception that in the past several years IP2 has reduced its resources dedicated to emergency preparedness. One EOC official said that there appeared to be less outreach by IP2 to the counties regarding emergency preparedness matters. He cited the difficulty he experienced in having telephone calls returned from IP2 regarding matters concerning the EOC. This assessment was echoed by another EOC official who also described a decreasing interaction between his EOC and IP2.

A third official told OIG that IP2 appeared to have experienced staff reductions in the area of emergency preparedness. This official said his staff has not had any recent visits to the site and most of his contact with IP2 has been by telephone. At times, this has been problematic. He speculated that the fact that IP2 was for sale may be a factor in the under-staffing of the

emergency preparedness staff.

Local and County Officials Seek Increased Interaction with NRC

A majority of the local and county officials interviewed by OIG recommended that the NRC increase its interaction with representatives of the local and county governments to keep them informed of events at IP2. OIG received a common complaint from the public officials that NRC failed to clearly communicate information to the public. One public official representing a community within the EPZ told OIG that NRC resident inspectors have been invited to their community meetings but they have not participated.

The OIG learned that the EOC official's interaction with the NRC was so limited that many did not know that NRC had resident inspectors assigned to the plant. As one EOC official told OIG, the NRC has "historically been invisible on issues that impact the community. The only time the public hears from the NRC is when the NRC announces its intention to hold a public meeting." This official also explained that any information his office received regarding the NRC's involvement with IP2 was obtained from the local media.

Another EOC official told the OIG that when Indian Point 3 was on the NRC's Watch List, he attended what he described to be NRC sponsored Quality and Assurance meetings. He said that he found the information presented in those sessions was beneficial. Consistent with the above, several EOC officials interviewed by OIG recommended NRC resident inspectors conduct routine briefings on the status of IP2. The exchange of information would be beneficial and would allow the EOC's to make timely modifications to their emergency plans. A majority of the EOC officials expressed their view that there should be more of a partnership between the NRC and the EOC officials.

OIG also discovered that several EOC officials believed that the NRC should serve as independent source from which they could obtain objective information regarding on-site conditions in either emergency or non-emergency situations. These officials believed that such a resource could be a valuable asset for the communities. They speculated that if such partnership existed on February 15, 2000, the EOC's would have been able to corroborate information about the incident which would have aided their performance.

III. Adequacy of NRC Staff's Review of IP2 Restart Proposal

Shortly after the February 15, 2000, event at IP2, NRC began a detailed technical dialogue with IP2 to understand the root cause of the steam generator tube failure and subsequent licensee corrective actions. On April 14, 2000, IP2 provided the NRC with its root cause analysis of the steam generator tube failure. Subsequently, on June 2, 2000, IP2 provided NRC a discussion of its corrective actions and justification for continued operation with the existing steam generators.

The NRC is conducting a comprehensive review of IP2's proposal to resume plant operation. In accordance with its operating license, IP2 must obtain NRC approval prior to plant start-up. OIG determined that the NRC staff has been extensively engaged on steam generator tube integrity activities at IP2 since the February 2000 event. Staff activities have included direct observation of steam generator inspections performed at IP2 and detailed review of inspection data and results as they relate to steam generator tube integrity. NRC has stated that approval of the restart of IP2 will not occur unless NRC concludes that the steam generators meet technical standards and will adequately protect public health and safety.

An NRC staff member expressed concern to OIG about the speed at which NRC was conducting its review of IP2's restart proposal. The NRC staff member was concerned that statements made by NRC senior management to IP2 appeared to overstate the staff's progress and could result in unreasonable expectations by IP2. Alternatively, the employee stated that such comments could result in undue pressure on the NRC technical staff by NRC senior management to fulfill IP2's expectations.

OIG interviewed a number of NRC staff members at Headquarters and Region I who have been involved in various aspects of the restart review. The NRC staff told OIG that they were not aware of constraints by NRC management to reach predisposed conclusions, nor were they aware of undue pressure placed upon them in the form of unreasonable time constraints or limits on the scope of their technical review.

An NRC reviewer noted that OIG's oversight of the staff's technical review to be beneficial in that it would help ensure that working-level staff were not pressured to reach a particular conclusion. The employee explained that, in terms of integrity of the process, working-level staff and managers were less likely to succumb to pressures from higher management if they were aware of OIG's presence.

FINDINGS

1. NRC's Oversight of Events Leading Up to the February 15, 2000, Steam Generator Tube Rupture at IP2

- OIG determined that the NRC and nuclear industry had long-standing concerns about the loss of integrity of steam generator tubes used on PWRs due to a variety of degradation mechanisms. Degradation problems particular to Westinghouse Model 44 steam generators resulted in all plants with this model steam generator replacing their steam generators, except IP2. The NRC has also been long aware of steam generator tube and other problems at IP2. Nevertheless, the NRC did not conduct a technical review of the July 29, 1997, IP2 steam generator inspection report when it was submitted to NRR. However, OIG noted that steam generator inspections are of sufficient importance to be included in plant technical specifications. IP2 technical specifications mandate steam generator inspections to be conducted no less than every 24 months and the inspection report to be submitted to the NRC no later than 45 days after completion of the inspection. OIG also found that had NRC staff or contractor's with technical expertise evaluated the 1997 results of the IP2 steam generator inspection, the NRC could have identified the flaw in the U-bend of row 2, column 5, in steam generator number 24 that was indicated in the inspection report. This flaw, which was recently determined to be nearly 100 percent through the tube wall in 1997, was the cause of the February 15, 2000, IP2 steam generator tube rupture. OIG found that the 1997 IP2 steam generator inspection results were not reviewed by the NRC staff for technical quality or sufficiency because the staff is not required to conduct such a review.

- OIG determined that NRR's review of a 1999 license amendment request submitted by IP2 was not adequate. The 1999 IP2 license amendment request number 201, asking for a 1 year extension for the steam generator inspection, was approved by NRR based on a safety evaluation completed by a junior engineer with limited experience in steam generator inspection techniques. The safety evaluation review included the junior engineer's evaluation of the 1997 steam generator inspection results. During the safety evaluation review process the junior engineer was supposed to receive assistance from a senior engineer with extensive steam generator experience. OIG determined that during the amendment review process, the senior engineer did not review the source documents submitted by IP2 nor did he review the 1997 IP2 inspection report. OIG also noted that other technical expertise available to the NRR staff was not employed to review the 1997 inspection report or the amendment request.

  OIG also found that during the amendment review process, the NRC requested additional information from IP2 in the form of an RAI to clarify outstanding issues relative the steam generator inspection program. Although the junior

engineer was not completely satisfied with the response to the RAI, no additional questions were asked by the NRC of IP2.

OIG found nearly no involvement in the amendment request review by either the NRR Project Manager assigned to IP2 or the EMCB Branch Chief. OIG also found that the NRR staff believed that the level of review given to IP2's license amendment request 201 was acceptable because steam generator issues at IP2 were not viewed as significant to NRC's oversight and regulation of the plant.

2. NRC Oversight of IP2 Emergency Preparedness Issues

- **!** OIG found that the NRC considered IP2 to be a plant that struggled with various challenges in the area of emergency preparedness, but the NRC decided that allowing IP2 time to correct its deficiencies outweighed the benefit of increasing NRC oversight.

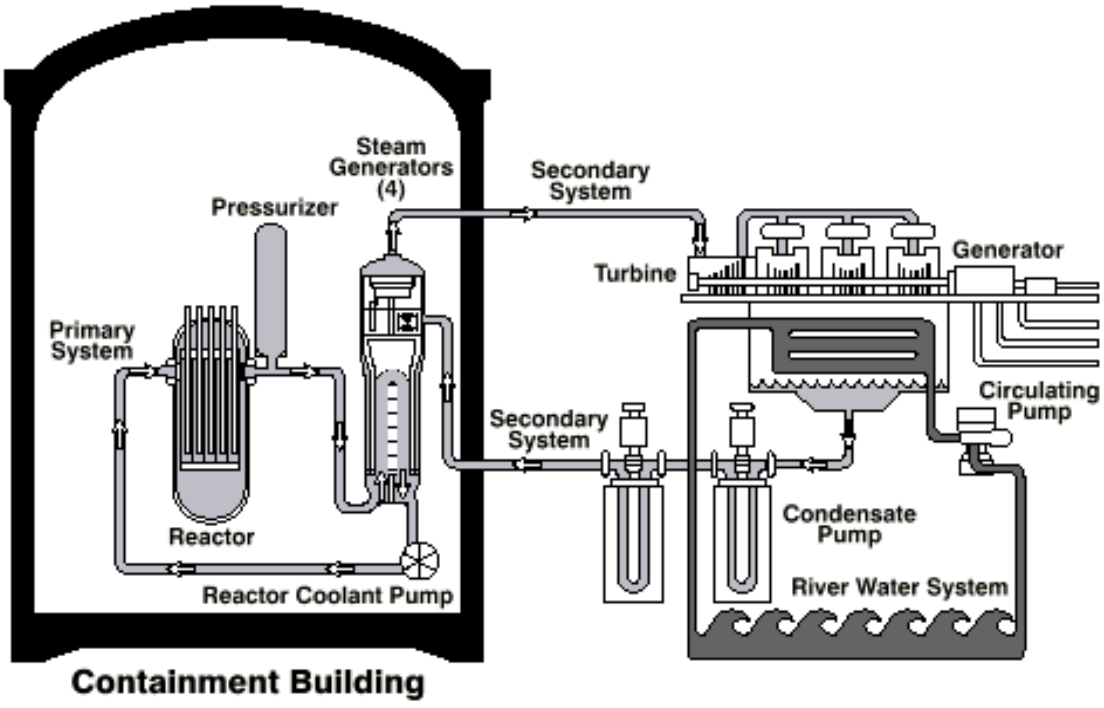
- **!** OIG also found that the NRC inspectors from Region I had concerns about licensee on-site performance during emergency preparedness exercises from 1998 to present. They had identified significant, long-standing weaknesses that had not been corrected. Because of IP2's poor performance in pre-announced drills of a known scenario, NRC inspectors questioned IP2's capability to perform during an actual event. OIG learned that recurring weaknesses that had gone uncorrected appeared to play a role in the poor emergency response performance of IP2 during the February 15, 2000, event.

- **!** Concerning off-site emergency preparedness issues, OIG found that communication between county EOCs and the NRC was non-existent. County officials view the NRC as the only independent source they have to provide them credible, objective information. Those officials desire personal interaction on a routine basis with the NRC staff of IP2 to discuss plant activities. OIG also determined that disjointed and misinformation from IP2 during the February 15, 2000, incident adversely impacted the off-site emergency preparedness process.

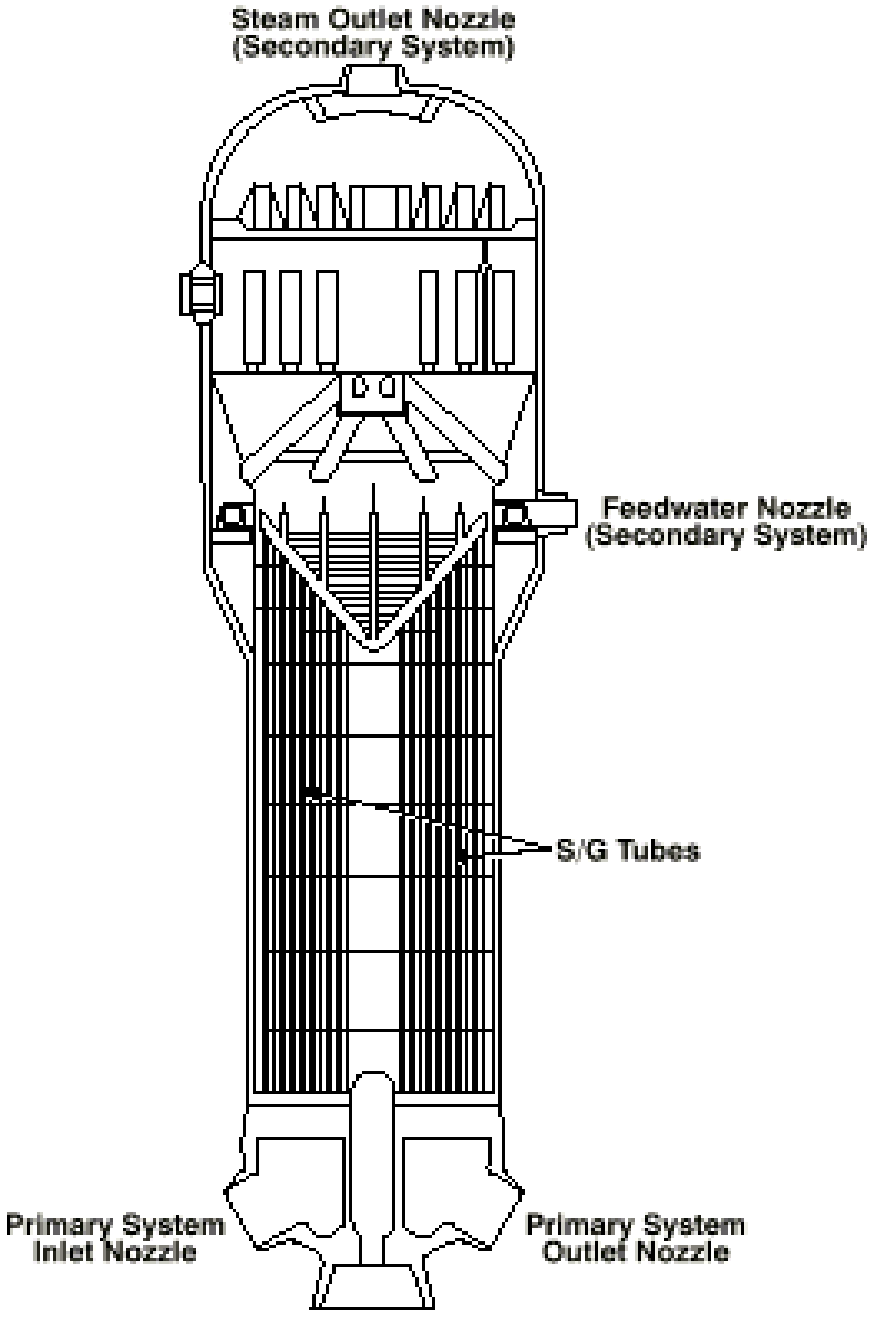
3. Adequacy of NRC Staff's Review of IP2 Restart Proposal

- **!** OIG found that, although there may have been some initial concerns by the NRC staff evaluating IP2's request for restart, NRC management has not allowed time constraints to impact on the staff's ability to conduct a thorough review of the data presented by IP2 in its June 2000 restart proposal.

Nuclear Power Plant (PWR)



Steam Generator (S/G)



LIST OF ACRONYMS

AIT	Augmented Inspection Team
BWR	boiling water reactor
CFR	Code of Federal Regulations
DE	Division of Engineering
DLPM	Division of Licensing and Project Management
DPV	Differing Professional View
EMCB	Materials and Chemical Engineering Branch
EOC	Emergency Operations Center
EP	emergency preparedness
EPA	U.S. Environmental Protection Agency
EPRI	Electrical Power Research Institute
EPZ	Emergency Planning Zone
ERO	Emergency Response Organization
FEMA	Federal Emergency Management Agency
GL	Generic Letter
gpd	gallons per day
id	inner diameter
IN	Information Notice
IP2	Indian Point Unit 2 Power Plant
ISI	inservice inspection
MEB	Materials Engineering Branch

mrem	millirem
NRC	U.S. Nuclear Regulatory Commission
NRR	Office of Nuclear Reactor Regulation (NRC)
NUE	Notification of Unusual Event
od	outer diameter
ODSCC	outer diameter stress corrosion cracking
OIG	Office of the Inspector General (NRC)
PWR	pressurized water reactor
RAI	request for additional information
RCS	reactor coolant system
RES	Office of Regulatory Research (NRC)
SCC	stress corrosion cracking
SER	safety evaluation report
SG	steam generator
SMM	Senior Management Meeting
TS	technical specifications

GLOSSARY OF TECHNICAL TERMS

Cold Shutdown - The term used to define a reactor coolant system at atmospheric pressure and at a temperature below 200 degrees Fahrenheit following a reactor cooldown.

Containment - A gas-tight structure or other enclosure around a nuclear reactor to confine fission products that otherwise might be released to the atmosphere in the event of an accident.

Cooldown - The gradual decrease in reactor fuel rod temperature caused by the removal of heat from the reactor coolant system after the reactor has been shutdown.

Degradation Mechanism - mechanical or chemical processes which effect deterioration of a component

Eddy-Current Techniques - A non-destructive examination procedure used in the inspection of steam generator tubes.

Fission Gases - Those fission products that exist in the gaseous state. In nuclear power reactors, this includes primarily the noble gases, such as krypton and xenon.

Fuel Cycle - The sequence of steps involved in supplying, using reprocessing, and disposing of the fuel used in nuclear reactors.

License Event Report (LER) - Reports submitted by licensees in accordance with 10 CFR 50.73 to notify the NRC within 30 days of the occurrence of any described in 10 CFR 50.73.

Millirem (mrem) - One thousandth of a rem.

Noble Gases - A gaseous chemical element that does not readily enter into chemical combination with other elements. An inert gas. Examples are helium, argon, krypton, xenon, and radon.

Pressurized Water Reactor (PWR) - A power reactor in which heat is transferred from the core to an exchanger by high temperature water kept under high pressure in the primary system. Steam is generated in a secondary circuit. Many reactors producing electric power are pressurized water reactors.

Primary System - A term that may be used for referring to the reactor coolant system.

Secondary System - The steam generator tubes, steam turbine, condenser, and associated pipes, pumps, and heaters used to convert the heat energy of the reactor coolant system into mechanical energy for electrical generation. Most commonly used in reference to pressurized water reactors.

Shutdown - A decrease in the rate of fission (and heat production) in a reactor (usually by the

insertion of control rods into the core).

Steam Generator (SG) - The heat exchanger used in some reactor designs to transfer heat from the primary (reactor coolant) system to the secondary (steam) system. This design permits heat exchange with little or no contamination of the secondary system equipment.

Technical Specifications (TS) - Part of an NRC license authorizing the operation of a nuclear production or utilization facility. A technical specification establishes requirements for items such as safety limits, limiting safety system settings, limiting control settings, limiting conditions for operation, surveillance requirements, design features, administrative controls, initial notification, and written reports. These are included in the 10 CFR Part 50 and have legal force and effect.

Safety Evaluation Report (SER) - The NRC staff evaluation of the licensees documents submitted for proposed changes to the nuclear plant, then used by NRC to determine whether to issue a construction permit or license, or to issue a license amendment for a major modification to the plant.

Whole-body Exposure - An exposure of the body to radiation, in which the entire body, rather than an isolated part, is irradiated.