SAIC-88/1814

TECHNICAL EVALUATION REPORT
INDIAN POINT STATION, UNIT 2
REVIEW OF REQUEST FOR APPROVAL TO SCHEDULE NEXT STEAM GENERATOR INSPECTION FOR THE SPRING 1989 REFUELING OUTAGE

TAC No. 67041

September 6, 1988

Science Applications International Corporation

Prepared for:

U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Contract NRC-03-87-029
Task Order No. 23

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8809130245 XA 25pp.

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1. INTRODUCTION

Science Applications International Corporation (SAIC) has been tasked by the Nuclear Regulatory Commission (NRC) to provide a technical review and evaluation of Consolidated Edison Company of New York's request for approval to schedule the next inspection of the Indian Point Unit 2 steam generators for the Spring 1989 refueling outage. The evaluation focused on the results of the 1987 refueling outage steam generator inspections, which include eddy current examination of the steam generator tubes, other examinations and inspections, and actions taken by the licensee to mitigate future steam generator tube corrosion.

This evaluation also addresses NRC concerns involving the presence of loose parts on the secondary side of the steam generators. The licensee's compliance with Technical Specifications and Generic Letters relating to steam generator inspection and repair are reviewed, as well as conformance to recommendations for secondary water chemistry controls and secondary side examinations resulting from Electric Power Research Institute (EPRI) and NRC research studies.

Reference (1) is a submittal to the NRC from Consolidated Edison Company of New York, Inc. (ConEd) containing the steam generator inservice inspection results from its 1987 (eighth) refueling outage of Indian Point Unit 2. The inspection program as described in the submittal included eddy current examination of the steam generator tubes, visual examination of the secondary side and the flow slots in tube support plates, chemical analyses of removed sludge deposits and ultrasonic examination of the J-tubes in steam generator 22.

Based on the results of these inspections, which included preventive plugging of defective and dented tubes, ConEd (the licensee) returned to power operation in January 1988. This is permissible in accordance with Technical Specification Section 4.13.C.4 (Ref. 2), which states "Restart after the scheduled steam generator examination need not be subject to NRC approval." However, the following Technical Specification item, 4.13.C.5, stipulates "In any event, NRC staff approval shall be obtained for operating for a period longer than eight equivalent months of operation or one calendar year from the date of restart after examination." The licensee therefore provided in the January 22, 1988 letter (Ref. 1) justification for NRC approval needed to schedule the next steam generator inspection to be conducted during the ninth refueling outage in the spring of 1989. This would be approximately 15 calendar months of operation from the date of restart after examination. Indian Point Unit 2 Technical Specifications provide for steam generator examination within twenty calendar months from the date of restart, subject to the NRC's approval.

The licensee's justification for operation in excess of one calendar year before tube inspections are performed is based on the 1987 inspection results, preventive tubes plugged, and other examinations and actions taken at that time. On May 3, 1988 the NRC staff requested additional information of the licensee concerning top support plate denting, foreign objects remaining in secondary side of the steam generators, and removal of copper containing secondary side components. The licensee provided answers to the NRC staff's request for additional information in a letter dated May 25, 1988 (Ref. 3). This letter gave answers to specific questions and included Westinghouse's Safety Analysis dated December 19, 1987. The January 22 and May 25, 1988 letters were the principal documents reviewed for this evaluation. The evaluation also considers the past tube leak history and steam generator tube examination results and plugging experience.

2. HISTORY

The following synopsis covers the background of Indian Point Unit 2 operations, previous inspections, and licensee actions taken to date.

Indian Point Unit 2 incorporates a nuclear steam supply system manufactured by Westinghouse, and is licensed for 873 MWe. Commercial operation was started in August 1974. The Unit has four Westinghouse Model 44 steam generators, each with 3260 Inconel Alloy 600 tubes. The plant's secondary water chemistry treatment was initially phosphate water chemistry which was changed to all volatile treatment in 1975.

Indian Point Unit 2 was one of six pressurized water plants identified in 1976 to be suffering from tube deformation or denting at support plate locations due to support plate corrosion product growth. Since that time the Indian Point Unit 2 steam generators have been monitored for denting by eddy current techniques or with the use of profilometry. In addition to denting there have been indications of pit-like corrosion of the tubes in the region of the sludge piles on the tubesheets. Both denting and pitting are attributable to the presence of copper on the secondary side of the steam generators.

There have been seven instances of primary-to-secondary leaks in the Indian Point Unit 2 steam generators, all below the Technical Specification limit of 0.3 gallons per minute (gpm) or 432 gallons per day (gpd). The distribution of leaks is as follows:

S/G 21 - None
S/G 22 - 1975, 1979, 1984
S/G 23 - 1981, 1981, 1986
S/G 24 - 1976

According to the Technical Specifications at Indian Point Unit 2 (Ref. 2), at least 12% of the tubes in each steam generator shall be subject to hot leg examination, and at least 25% of these tubes shall be subject to cold leg examination. Examinations for defects, pits and wall-thinning shall be by eddy current techniques and examinations for deformation (dents) shall be either by eddy current or by profilometry.

Recent steam generator inspection programs have included, in addition to Technical Specification requirements, (1) photographs of support plate flow slots, (2) secondary side examinations using TV cameras, and (3) steam generator sludge removal and analysis.

The 1986 eddy current examination of steam generator tubes was performed during the seventh refueling outage and resulted in the plugging of 112 tubes due to corrosion degradation and denting. The distribution of tube plugging in 1986 and total tubes plugged is as follows:

	Plugged 1986	Previously Plugged	Total Plugged	Total % Plugged
S/G 21	28	149	177	5.4
S/G 22	49	200	249	7.6
S/G 23	13	136	149	4.6
S/G 24	22	179	201	6.2

Along the chord of the innermost row of tubes in the Indian Point Unit 2 steam generators, there is a row of rectangular flow slots in the tube support plates. When pressure builds up in the tube support plate due to the tube denting phenomenon, the flow slots have been observed to deform (the "hourglassing" effect); that is, the central portion of the flow slots walls moves closer, so that some flow slots are narrower in the center than at the ends. Flow slot closure or "hourglassing" is a manifestation of the denting process and therefore photographs of the flow slots to measure progression of denting have been taken at the Indian Point Unit 2 at each inspection.

Copper-containing corrosion products from copper alloy secondary system components build up in the sludge pile on the tubesheets, and act with oxygen and chloride ions in condenser inleakage to pit steam generator tubes in the sludge pile regions. Sludge lancing to remove the copper containing sludge on top of the tubesheets was performed at Indian Point Unit 2 during the 1984 and 1986 refueling outages. The amounts of sludge removed are as follows:

Pounds of sludge removed

	1984	1986
S/G 21	363	38
S/G 22	543	123
S/G 23	217	75
S/G 24	270	96
Total	1393	332

During 1984 tube inspections the licensee attributed interference with eddy current signals to copper deposits on the steam generator tubes. In order to remove the copper deposits the pH of the steam generator lay-up water was raised to 10.5, and a series of cycles of fill, soak, and drain operations were performed. These operations were successful in removing significant amounts of copper from each steam generator. The amounts of copper removed are as follows:

S/G 21 - 35 lbs
S/G 22 - 38 lbs
S/G 23 - 26 lbs
S/G 24 - 24 lbs

The admiralty brass condensers and copper alloy tubed heat exchangers are the principal Indian Point Unit 2 secondary side components which contain copper alloys. Since 1982 the licensee has had a program for replacing these components. During the 1982 refueling outage high pressure copper containing feedwater heaters designated No. 26A, 26B and 26C were replaced with austenitic stainless steel tubed heaters.

In addition to copper, corrosion initiated damage to Inconel Alloy 600 steam generator tubes is due to oxygen and chloride ions from condenser inleakage which act synergistically with copper to form acidic solutions in local regions such as crevices and the sludge pile. The secondary water chemistry monitoring and control program at Indian Point Unit 2 for oxygen and chlorides shows the following average values for some of the periods between 1978 through 1986 (Ref. 4):

Year	Average Condenser Air inleakage (standard cubic feet/minute)	Dissolved Oxygen (parts per billion)	Average ppb Chloride in Steam Generator blowdown
1978-79	32	10	68
1979-80	20	3	63
1981-82	11	2	41
1983-84	12	13	54
1984-86	10	9	34

ConEd is presently utilizing the Electric Power Research Institute (EPRI) Revision 1 of "PWR Secondary Water Chemistry Guidelines" issued in June 1984 for its secondary water chemistry control and monitoring program (Ref. 5).

In 1982 ConEd installed a Metal Impact Monitoring System (MIMS) at Indian Point Unit 2 to provide detection of loose metallic parts impacting within the reactor coolant system (reactor system and primary side of the steam generators) and secondary side of the steam generators. By utilizing microprocessor technology, the MIMS provides continuous and automatic data reduction as well as display of all essential information to plant operators.

The first secondary side visual examinations for loose parts were conducted at Indian Point Unit 2 during the 1982 refueling outage inspection. A television camera was passed across the tube lanes via the 6" handholes in such a way as to observe the spaces or lanes between the columns of tubes. During the 1984 steam generator examinations, fiber optics were used in the secondary sides of all the steam generators along the tube lanes and along the entire periphery of the tube bundles. In addition to looking for loose parts of foreign objects on the tubesheets, the purpose was to look for external damage to peripheral tubes just above the tubesheets.

During these examinations no visual damage to tubes was detected, but several foreign objects were found in each steam generator. For example, one object was identified as typical of a screw from a device used by Westinghouse for positioning support plates. Another object could be moved vertically but could not be dislodged. All the remaining objects were fixed firmly in the tube bundles. The licensee postulated that these objects were in the steam generators from the time of final assembly. An inventory of five objects remaining in the steam generators after the 1984 inspections is as follows:

	Item	Size	Location	Position
S/G 21	Plate	1/4"x1"x? lg	Inlet R15-16, C3-5, Nozzle Side	Protruding from bundle between tubes
S/G 22	Rod	1/8"x10" lg	Outlet, R14-15, Manway Side	Back into bundle 4-5 columns
S/G 23	Plate	1/4"x1"x? lg	Inlet, R36-37 Nozzle Side	Protruding from bundle between tubes
S/G 23	Cylinder	3/4"x1" lg	Inlet, R35-36 Nozzle Side	Resting in front of the plate on the tubesheet
S/G 23	Rod	1/4"x? lg	Inlet, R43, C32-33	Protruding from the bundle and extending to the shell

Tubes R15 C3, R15 C4, R15 C5 and R16 C5 adjacent to the entrapped plate in steam generator 21 were plugged. As a precautionary measure to eliminate damage to the active tube bundle from possible wear of these tubes by the entrapped objects, the tubes were also "stabilized" by bars that extended from the plugs through the tubesheet to the lowest support plate.

Five additional foreign objects were discovered during the 1986 steam generator inspections. Eddy current examination of adjacent tubes showed no indication of degradation wear. At ConEd's request, Westinghouse calculated the approximate time for the impact and sliding motion of a tube on an object to wear a tube with a 0.050 inch nominal tube wall thickness to a minimum allowable wall thickness of 0.021 inch for the five foreign objects remaining in the steam generators (Ref. 3, Attachment 2). These estimated wear times are shown below.

Steam Generator	Object Description	Location	Best Estimate Wear Times
22	Wire	R44 C35-38	2.0 years
	Electric Wire	R1 C40	1.8 years
	Pipe Tap	R22,23 C7	1.7 years
23	Rod	R43 C32,33	2.04 years
24	Wire	R45 C44,45	2.0 years

Westinghouse concluded that the steam generators could operate safely for at least a period of one fuel cycle between inspections.

The Indian Point Unit 2 program for detection of primary system to secondary side leakage is based on Xenon-133 measured in the condenser air ejector discharge. ConEd prefers the method because Xenon is very volatile and does not have to be decay corrected to water mass turnover time. The Xenon-133 method is accurate to 0.001 gpm (1.5 gal/day). The monitoring of activity is either continuous as measured by condenser air ejector radiation monitor or by grab sample and provides a rapid response to any leakage. In addition, the steam generator blowdown stream is monitored for radiation and grab samples can be used for tracking Na-24, I-131 or I-133, relative to corresponding Reactor Coolant System activities to determine primary-to-secondary leakage. All monitoring systems are covered by existing Technical Specifications operability and surveillance requirements.

In a letter dated July 20, 1987 (Ref. 6) ConEd submitted to the NRC details of its proposed steam generator inservice inspection program for the 1987 (eighth) refueling outage. The proposed inspection program is described in the licensee's July 20, 1987 letter as follows:

"100% inspection of all tubes to the first support plate elevation.

"The following tube sample sizes will be inspected above the first support plate:

	Hot Leg	Cold Leg
S/G 21	23.8%	4.5%
S/G 22	24.7%	5.7%
S/G 23	19.5%	4.3%
S/G 24	21.5%	4.6%

"Inspections will be conducted with a 0.700 inch diameter probe. If any tube does not permit passage of the 0.700 inch diameter probe (as a result of denting), the tube will be tested with a 0.610 inch diameter probe. Any tube not permitting passage of a 0.610 inch diameter will be plugged.

"In each steam generator, the eddy current examination will include tubes in the patch plate and peripheral "hard spot" areas, tubes in Rows 2 and 3, and a sample of tubes in the interior section of the bundle.

"The support plate flow slots will be visually inspected for deformation (caused by denting).

"A video camera or boroscope inspection of the annulus between the tube bundle and shell and down the tube lane will be conducted for foreign objects and/or loose parts."

The licensee provided the NRC staff with supplemental information in response to staff questions and the NRC then issued a Safety Analysis Report on October 6, 1987, (Ref. 7) approving ConEd's proposed eighth refueling outage steam generator inspection program.

3. DISCUSSION

In this section we summarize the scope and results of the current inspection and the licensee justification for scheduling the next steam generator inspection.

In its letter submittals dated January 22, 1988 and May 25, 1988, (Refs. 1,3) ConEd provided a description of the scope and results of the steam generator examinations performed during the 1987 refueling outage at Indian Point Unit 2. Included in these submittals was justification for scheduling the next steam generator inspections during the spring 1989 (ninth) refueling outage, which would result in approximately a 15-month calendar interval between inspections.

3.1 Scope of Steam Generator Inspections

3.1.1 Tube Eddy Current Examinations

All unplugged (in service) tubes in the four steam generators were eddy current examined from the tubesheet to the first tube support plate. Selected tubes, based on the results of previous inspections were further eddy current examined for dents and defects. Hot-leg examinations were those examinations conducted from the hot-leg side of the channel head, around the U-bend, to the uppermost support plate on the cold-leg side. Cold-leg examinations were full length examinations which encompassed cold-leg entry at the tubesheet through the hot-leg tubesheet. The tubes selected for hot-leg examinations included tubes in the patch plate and peripheral "hard spot" areas, a sampling of tubes in the interior of the tube bundle, and all unplugged tubes in Rows 2 and 3. (All tubes in Row 1 have been previously plugged.) Technical Specifications for Indian Point Unit 2 require that hot-leg examinations be conducted on a minimum of 12% of the tubes in each steam generator, and that at least 25% of the tubes subjected to hot-leg examination be cold-leg examined.

The number of tubes examined in each steam generator is as follows:

	Hot-leg	Cold-leg
S/G 21	766 - 24.8%	141 - 18.4%
S/G 22	736 - 24.5%	178 - 24.2%
S/G 23	637 - 20.5%	135 - 21.2%
S/G 24	662 - 21.7%	140 - 21.1%

In its January 22, 1988 letter, ConEd identified each of the tubes examined (Ref. 1, Tables 1, 2, 3, and 4).

Multi-frequency eddy current techniques with capability for digital data analysis were used for the inspections. The frequencies used were 10/200/400 and 600 kHz. The 600 kHz signal was mixed with the 200 kHz signal to suppress the effect of copper deposited on the outside of the tube.

3.1.2 Flow Slot and Lower Support Plate Inspection

Visual and photographic examinations for flow slot closure due the tube denting in the lower tube support plates were made. These inspections were made through entry from the handholes above the tubesheet. Examinations for cracks in the lower support plates at the flow slots were also made. The cracks appear in the ligaments between the flow slot and the first row tube holes and are a consequence of continued magnetite growth in the tube to tube support plate annulus at those locations.

3.1.3 Top Support Plate Flow Slot Examinations

Using the "hillside" inspection ports in steam generators 22 and 23, visual and photographic examinations were made of the flow slots in the upper support plates.

3.1.4 Secondary Side Examinations

A search for loose parts and foreign objects was conducted using a video camera which was passed around the annulus between the tube bundle and the shell, and down the tube lanes between the hot-legs and cold-legs.

3.1.5 Sludge Lancing and Sludge Analysis

Each of the steam generators was sludge lanced to remove the loose sludge on top of the tubesheets. The removed sludge deposits were analyzed for copper and iron content.

3.1.6 J-Tube Examinations

Ultrasonic examinations were performed on selected J-tubes in steam generator 22 to determine whether there was metal loss or any unusual wear patterns.

3.2 Results of Examinations

The following discussion summarizes the examination results presented in ConEd's January 22 submittal to the NRC.

3.2.1 Results of the Tube Examination

At the end of 1986 there was a total of 776 plugged tubes in the Indian Point Unit 2 steam generators. Of this total 112 tubes were plugged as a result of the 1986 refueling outage inspections.

A total of 146 tubes with eddy current indications, below the plugging limit of $\geq$40% degradation of the tube wall thickness, were left in service at the end of 1986. In the 1987 inspection of these tubes 28 were found not to have any indications. In 62 of these tubes the indications were reported to approximately the same size ($\pm$10%), in 11 tubes the indications were reported to be smaller, and in 45 tubes indications were reported to be larger.

Of the 45 tubes reported to have increases in the eddy current indications the maximum single increase was 37% and the average increase was 15%. Of 39 tubes in which indications were reported to be smaller (or to have disappeared) in 1987, the maximum single decrease was 39% and the average decrease was 24%. The licensee therefore contends it is not possible to derive a degradation "growth rate" from eddy current examinations.

In absolute terms, 90 tubes were plugged because of indications evaluated at 40% of the wall thickness or greater.

Nineteen (19) tubes were plugged because of deformation or denting; these tubes would not permit passage of a 610 mil diameter probe, a Technical Specification requirement.

The following tables from ConEd's submittal (Ref. 1) show the distribution of tubes with eddy current indications, tubes plugged due to denting, and summary of all plugged tubes.

NUMBER OF TUBES WITH EDDY CURRENT INDICATIONS
(PERCENT WALL THINNING)

S/G NO.	LEG	20-29%	30-39%	40-49%	50-59%	60-69%	>70%
21	Hot	2	2	0	0	1	0
21	Cold	25	34	9	4	3	0
22	Hot	14	8	4	0	1	0
22	Cold	26	33	4	5	2	0
23	Hot	18	19	4	3	1	0
23	Cold	3	10	6	7	6	1
24	Hot	24	9	0	0	0	0
24	Cold	16	31	13	8	8	0

(Ref. 1, Table 5)

NUMBER OF TUBES PLUGGED IN 1987
BECAUSE OF TUBE RESTRICTIONS

S/G 21	3
S/G 22	0
S/G 23	11
S/G 24	5

(Ref. 1, Table 7)

SUMMARY OF PLUGGED TUBES

S/G NO.	Plugged in 1987	Previously Plugged	Total	Percent Now Plugged
21	22*	177	199	6.1
22	16	249	265	8.1
23	39	149	188	5.8
24	34	201	235	7.2
Total	111	776	887	6.8

* Includes 2 tubes plugged with sentinel plugs because of North Anna-related concerns (potential for fatigue damage).

(Ref. 1, Table 8)

3.2.2 Results of Flow Slot and Lower Support Plate Examinations

There was essentially no change in flow slot closure or "hourglassing" due to continued tube denting from that seen in the previous inspection.

No changes were observed in cracks in the lower tube support plates at the flow slots observed in previous steam generator examinations.

3.2.3 Results of Top Support Plate Flow Slot Examinations

The boroscopic examinations of top support plates in steam generators 22 and 23 did not reveal any "hourglassing" of the flow slots in these support plates.

3.2.4 Results of Secondary Side Examinations

Two new foreign objects were located on the tubesheet of the secondary side of steam generator 22. They are (1) 0.375"x0.375"x3"-4" long metallic bar and (2) 0.125" diameter by 4" long piece of weld rod. A foreign object search and retrieval effort which was unsuccessful. The metallic bar is lodged between R42 and R43 Columns 31-33. The piece of weld rod is stuck to the tubesheet in the annulus, oriented parallel to the bar; both are on the outer periphery of the bundle.

NRC Generic Letter 85-02, Section 1.a (Prevention and Detection of Loose Parts) (Ref. 8) does not address the possibility of foreign objects remaining in the steam generator. Westinghouse prepared a Safety Evaluation Report IPP-87-979 dated December 17, 1987 that was attached to the ConEd letter submittal of May 25, 1988 (Ref. 3). It addresses the continued operation of the Indian Point Unit 2 steam generators with foreign objects remaining in the secondary side of the generators. The evaluation addressed the fifteen objects remaining in the steam generators and covered the period of time until the next (ninth) refueling outage in the spring of 1989.

Westinghouse considered the possibility of a large leakage event due to severance near the tubesheet of a structurally degraded plugged peripheral tube and its interaction with an active tube resulting in leakage of the active tube due to wear, and concluded that the mass of objects remaining in the steam generators are positioned such that the impact of an object on an inactive tube would not result in tube collapse and subsequent fatigue to the point of severance of tube during the next fuel cycle.

Considering possible leakage due to wear of an active tube by an adjacent tube, best estimate wear evaluations were conducted on the objects to calculate the approximate time for impact and sliding motion of the tube on the object to wear the tube to a minimum allowable wall thickness of 0.021 inches. This ensures that tube integrity will be maintained for normal, upset and accident load conditions as defined in the Technical Specifications. The results of these evaluations indicated that the wear time estimates for the 15 foreign objects remaining in the steam generators range from 1.7 to 32.1 years of allowable operation and therefore tube integrity can be maintained until the next inspection (approximately 1.25 years) assuming constant wear of the objects on adjacent tubes. In addition, Westinghouse believes that the two objects with the shortest best estimate wear times (electric wire and pipe tap in steam generator 22) are immersed in an accumulation of sludge and therefore shielded from secondary cross flow and unlikely to move. This contention is supported by the fact that no change has been observed in the position of these objects since 1986.

Westinghouse cites the following eddy current evidence as an indication of the conservatism of their wear evaluations. For the five objects discovered in the 1986 inspections, the best estimate wear times were 1.7, 1.8, 2.0, 2.0, and 2.04 years (see table in Section 2 of this review). Although these wear times were calculated in 1986, Westinghouse believes that they remain valid beginning after the 1987 inspection, as the objects have remained in place since the 1986 inspections and there has been no indication of tube degradation.

3.2.5 Results of Sludge Lancing and Sludge Analysis

A total of 1049 pounds of sludge was removed from the Indian Point Unit 2 steam generators, broken down as follows:

S/G NO.	AMOUNT OF SLUDGE
21	306 lbs
22	201 lbs
23	316 lbs
24	226 lbs

(Ref. 1, Table 9)

The sludge consisted of approximately 57% iron, 33% copper and 10% insolubles.

3.2.6 Results of J-Tube Examination

The licensee indicated via a telecommunication that ultrasonic examination of J-tubes in steam generator 22 did not reveal any anomalies.

3.3 Secondary System Modifications

ConEd has been replacing copper bearing materials in the secondary system with austenitic stainless steel in an effort to eliminate copper transport to the steam generators. The only copper alloy-tubed heat exchangers remaining in the system are the condenser and low pressure feedwater heaters 21A-C and 22A-C which are located in the condenser neck. ConEd states in the May 25 submittal (Ref. 3) that the copper content of feedwater leaving the high pressure heaters was reduced from 5-30 ppb to 1-7 ppb following replacement of the heaters in 1982.

3.4 Secondary Water Chemistry

During 1986-1987 chlorides in the steam generator blowdown averaged 18 ppb, less than the 20 ppb established by the Steam Generators Owners Group Guidelines. Previous blowdown values have been above these guidelines. Air inleakage and dissolved oxygen values showed general improvement as a result of ConEd's attention to condenser tube leaks. The annual average chemical data for recent years is show below (Ref. 4):

Year	Average Condenser Air Inleakage (standard cubic feet/minute)	Dissolved Oxygen (parts per billion)	Average ppb Chloride Steam Generator blowdown
1983-84	12	13	54
1984-86	10	9	34
1986-87	5	4	18

3.5 Justification for Operating Interval Exceeding One Calendar Year Until the Next Steam Generator Inspections

Con Edison states that the results of the 1987 steam generator examination demonstrate that the Indian Point Unit 2 steam generators are acceptable for continued full power service until the next (ninth) refueling outage at which time the steam generators will be inspected. The Technical Specifications require that an inspection interval exceeding one calendar year be approved by the NRC. ConEd cites the following to justify the planned inspection schedule:

- Steam generator leakage experience has been good. There have been only seven instances of primary-to-secondary leakage; all were small and below the Technical Specification limits of 0.3 gpm.
- There has been no increase in tube degradation when the unit was returned to service following any of the refueling/maintenance steam generator examinations.
- As a result of the 1987 examinations, tubes which showed degradation $\geq$40% or did not pass a 610 mil probe were taken out of service (plugged).
- The tube leakage assessment program has been voluntarily updated to detect incipient leaks to assure that any sudden increase will be properly analyzed and appropriate mitigating actions are taken.

ConEd's enhanced leak detection and corrective action procedures require logging condenser air ejector monitor readings and graphically plotting the leak rate once every two hours if the leak rate is equal to or greater than 0.05 gpm. If three consecutive projected leak rate calculations indicate the leakage will be equal to or exceed 0.2 gpm within 24 hours, the unit load will be reduced to 50% within 2 hours. If the leak rate is equal to or greater than 0.2 gpm the unit will be shut down (Ref. 9).

4. EVALUATION

This evaluation addresses the licensee's inspection program scope, inspection and examination results, status of foreign objects remaining in steam generators, and program to reduce further corrosion.

An in-depth review of Indian Point Unit 2 1987 refueling outage steam generator inspection program results has been conducted to assess the acceptability for continued full power service of the steam generators until a proposed schedule of steam generator inspections at the next refueling outage in the spring of 1989. The primary purpose of this evaluation is to provide a technical review of ConEd's request for approval for a steam generator operating interval of 15 calendar months. This interval exceeds the minimum of eight full power equivalent months of operation (or one calendar year from date of restart) permitted without NRC approval, but is within the 20 calendar month limit imposed by the Technical Specifications.

The 1987 inspection program, which included eddy current tube examinations, support plate inspections, secondary side examinations and sludge lancing, was conducted in accordance with Technical Specification requirements, with the exception of the percentage of tubes subjected to cold-leg examination. It was carried out in the detail described in the licensee's letter of July 20, 1987 (Ref. 6) which was approved by the NRC staff by letter dated October 6, 1987 (Ref. 10).

The inspection scope was designed to encompass all those areas in the tube bundle and those tubes where previous inspections had indicated tube degradation or denting was occurring, including antivibration bar areas as recommended in NRC Bulletin 88-02 (Ref. 11), which addresses the North Anna Unit 1 rupture.

SAIC finds that as a result of the eddy current examinations, Technical Specification plugging limits for plugging defective tubes and deformed or dented tubes have been complied with.

This review finds that ConEd's program for monitoring any increases in denting as evidenced by measurement of support plate flow slot closure and analysis of eddy current dent signals is satisfactory, and is consistent with the approach described in NUREG-0523 "Summary of Operating Experience with Recirculating Steam Generators" (Ref. 12).

ConEd's continuing program of replacing secondary system components containing copper alloys with austenitic stainless steel has proven successful in reducing the introduction of corrosion promoting copper into the secondary side of the steam generators. This is shown by the reduction in copper content after replacement of some of the high pressure feedwater heaters in 1982. Further reductions in secondary water copper content are anticipated as a result of feedwater heater replacements made during the 1987 refueling outage.

This review also finds that ConEd's secondary water chemistry control program and condenser leak monitoring and maintenance program have been successful in lowering condenser inleakage and the dissolved oxygen and chloride content of the secondary water.

We find that ConEd has also been responsive to Generic Letter 85-02 (Ref. 6) in which the NRC staff requested that PWR licensees perform visual inspections of steam generator secondary sides in the vicinity of the tubesheet along the entire periphery of the tube bundle and the tube lane to identify the presence of any loose parts or foreign objects, and damage to the external surfaces of the tubes. ConEd has conducted visual examinations of the secondary side of the Indian Point Unit 2 steam generators during the 1982, 1984, 1986 and 1987 refueling outages. In all these examinations foreign objects have been observed and retrieved where feasible.

On the basis of the eddy current evidence of no wear of tubes adjacent to foreign objects remaining in the secondary side of the steam generators between the 1986 and 1987 inspection interval, SAIC accepts the licensee's contention that steam generator tube integrity will not be impaired by the presence of the foreign objects remaining in the steam generators until the scheduled (Spring 1989) steam generator inspections are performed.

Based on the above cited factors, the licensee's compliance with the Technical Specifications and the NRC recommendations addressing steam generator tube integrity has been satisfactory.

5. CONCLUSIONS

This review and evaluation is based on letter reports dated January 22, 1988 (Ref. 1) and May 25, 1988 (Ref. 3), submitted by Consolidated Edison Company of New York, Inc. Conclusions are based on steam generator inspection and examination results, preventive tube plugging, secondary system modifications, secondary system water chemistry controls, wear analyses relating to foreign objects remaining in the steam generators and enhanced leak monitoring procedures.

Based upon evaluation of the above cited factors, it has been concluded that Indian Point Unit 2 may be operated until the next (ninth) refueling outage before conducting scheduled steam generator inspections without undue risk to the public health and safety.

However, in view of the past history of low level tube leaks the newly instituted primary-to-secondary leak monitoring procedures and administrative controls for orderly shutdown due to small leaks should be maintained to minimize the probability of a forced shut down due to leakage.

Visual examinations of the secondary side for foreign objects and loose parts and for external damage to tubes adjacent to foreign objects or loose parts should be conducted at the next inspection outage. Additionally, efforts to retrieve the foreign objects remaining in the steam generators should be considered at the next (ninth) refueling and steam generator inspection outage.

REFERENCES

(1) "Steam Generator Tube Inservice Inspection Program: 1987 Inspection Program Results," Letter to NRC from Con Edison, dated January 22, 1988.

Attachment I: "Steam Generator Examination Program and Results 1987 Refueling Outage," Docket No. 50-247.

(2) Indian Point Unit 2, Technical Specification Section 4.13.

(3) "1987 Steam Generator Tube Inservice Inspection Program: Supplemental Information," Letter to NRC from Con Edison, dated May 25, 1988.

Attachment I: "1987 Steam Generator Tube Inservice Inspection Program Response to NRC's May 3, 1988 Request for Supplemental Information."

Attachment II: Westinghouse Safety Evaluation Report IPP-87-979, "Indian Point Unit No. 2 Safety Analysis for Plant Operation During Cycle 9 with Foreign Objects in the Secondary Side of Steam Generators," SECL-87-644, Rev. 1, dated December 17, 1987.

(4) Inspection Number 50-247/88-06, Region I Inspection Report, April 20, 1988.

(5) "PWR Secondary Water Chemistry Guidelines," Rev. 1, issued by the Electric Power Research Institute (EPRI) June, 1984.

(6) Steam Generator Tube Inservice Examination Program planned for IP-2's eighth refueling outage, submitted to NRC by ConEd letter dated July 20, 1987.

(7) Proposed Steam Generator Inspection Program for Indian Point Nuclear Generating Unit No. 2, NRC Letter dated October 6, 1987.

(8) Generic Letter 85-02 (Visual Inspections of SG Secondary Sides in the Vicinity of Tubesheet, etc.) dated April 17, 1985)

(9) Susceptibility of Indian Point Unit No. 2 Steam Generator to High Cycle Fatigue/Tube Failures, December 23, 1987.

(10) NRC Approval dated October 6, 1987.

(11) NRC Bulletin 88-02, Rapidly Propagating Fatigue Cracks in Steam Generator Tubes, February 5, 1988.

(12) NUREG-0523 "Summary of Operating Experience with Recirculating Steam Generators."