James S. Baumstark
Vice President
Nuclear Engineering

Consolidated Edison Company of New York, Inc.
Indian Point 2 Station
Broadway & Bleakley Avenue
Buchanan, New York 10511

Internet: baumstarkj@coned.com
Telephone: (914) 734-5354
Cellular: (914) 391-9005
Pager: (917) 457-9698
Fax: (914) 734-5718

May 15, 2000

Re: Indian Point Unit No. 2
Docket No. 50-247

Document Control Desk
US Nuclear Regulatory Commission
Mail Station P1-137
Washington, DC 20555-0001

Subject: Response to Request for Additional Information – Proposed Steam Generator Tube Examination Program – Supplement One (TAC No. MA8219)

Pursuant to 10 CFR 50.54(f), Consolidated Edison Company of New York, Inc. (Con Edison) hereby provides a completed Appendix K of the EPRI Steam Generator Guidelines checklist. This represents Con Edison's response to Question 9 contained in the staff's request for additional information dated March 24, 2000 regarding the RFO 14 steam generator tube examination program.

No new regulatory commitments are being made by Con Edison in this correspondence.

Should you or your staff have any concerns regarding this matter, please contact Mr. John McCann, Manager, Nuclear Safety & Licensing.

Sincerely,

Attachment

A001

C Mr. Hubert J. Miller
Regional Administrator-Region I
US Nuclear Regulatory Commission
475 Allendale Road
King of Prussia, PA 19406

Mr. Jefferey F. Harold, Project Manager
Project Directorate I-1
Division of Regulatory Projects I/II
US Nuclear Regulatory Commission
Mail Stop 14B-2
Washington, DC 20555

Senior Resident Inspector
US Nuclear Regulatory Commission
PO Box 38
Buchanan, NY 10511

Attachment

Response to RAI Question 9

Consolidated Edison Company of New York, Inc.
Indian Point Unit No. 2
Docket No. 50-247
May 2000

Indian Point Unit 2
EPRI PWR Steam Generator Guidelines
Appendix K Checklist
2R14 Spring 2000 Outage

Summary

Appendix K of Revision 5 of the EPRI PWR Steam Generator Guidelines, "Inspection Requirements Due to Leakage Forced Outages," provides guidance for all leakage-forced outages, irrespective of whether they exceed or do not exceed plant technical specification leakage limits, and ensures that the steam generators have adequate structural and leakage integrity for the remainder of the fuel cycle.

In the event of an outage due to leakage, Appendix K requires specific near term actions including determination of the location of the leak, flaw evaluation by bobbin, RPC and other NDE techniques, a review of historical and current NDE data, determination of the susceptible population, and review of previous engineering analyses. An evaluation of the adequacy of the steam generator inspection program is required to identify changes and/or upgrades necessary to ensure that inspections performed during the leakage outage meet the required criteria. Suitable repairs must be identified and implemented. Insitu pressure testing must be considered as a means of evaluating the structural and leakage integrity of specific forms of degradation. A root cause evaluation is required and suitable repairs performed to return the steam generator(s) to a state where they can be declared operable. Finally, a tube integrity assessment must be performed prior to plant restart to confirm that the tubes will retain adequate structural and leakage integrity until the next scheduled inspection.

After any leakage outage, development of long-term actions directed at providing reasonable assurance of operating without exceeding Regulatory Guide 1.121 and plant technical specification limits for the planned operating interval is required. The plant steam generator inspection program should be reviewed to assess the need for updating or improving. This could involve increasing the inspection sample, development of improved analysis techniques, upgrading analyst training, or testing, evaluating and qualifying equipment and/or techniques.

In support of the recovery efforts associated with the R2C5 leak event at Indian Point Unit 2, a multi-discipline team has been assembled by ConEd. Participation on this team includes personnel from ConEd, Altran, Westinghouse, and other technical consultants. An action plan has been developed which follows the guidance provided in Appendix K, Revision 5 of the EPRI Steam Generator NDE Examination Guidelines.

The following is a partial list of actions, completed or in progress to address the leakage event:

- The leak location has been identified as the U-bend area of R2C5 in steam generator 24
- Primary and secondary side visual examinations have been conducted in a successful effort to locate the leak area of R2C5
- Bobbin and Plus Point inspection have been performed on R2C5 to further characterize the indication as PWSCC and confirm its location at the apex of the U-bend on the tube extrados
- A review of industry experience for U-bend cracking has been performed
- Data from the 1997 examination of R2C5 have been reviewed
- Row 2 U-bends in all steam generators have been identified as critical areas (C-A)
- Row 3 U-bends in all steam generators have been defined as the buffer zone
- Row 4 U-bends in all steam generators have been added to the +Point low row U-bend inspection program to add conservatism
- Identified changes in the analysis process to improve resolution capability
- Applied the 800 kHz +Point probe for improved resolution of PWSCC in the U-bends
- Factored present eddy current information, including improved analysis methodology and techniques, into analyst training and site guidelines to support existing outage efforts
- Conducted examinations of the C-A and buffer zone applying improved analysis methodology and 800 kHz +Point techniques
- Reviewed all prior eddy current inspection results for row 2 and 3 U-bends, including reason for plugging, size and type of probes used, and level of tube restriction versus tube support plate elevation
- Reviewed all prior eddy current inspection results for level of tube restriction as a function of support plate elevation
- Investigated industry experience and Indian Point Unit 2 experience with PWSCC initiation and growth rates
- Investigated potential differences in material, manufacturing processes, etc., for row 2, 3, and 4 U-bends
- Performed a secondary side visual inspection of upper-most tube support plates to determine condition of the flow slot regions
- Updated existing stress models for upper-most support plate and U-bend region based on above findings
- Based on present and prior inspection results, thermal history, and stress condition determined growth rates for indications reported in row 2 U-bends
- Evaluated details of R2C5 leak event and determine primary-to-secondary leak detection strategy
- Conducting secondary side pressure testing prior to start-up
- A root cause analysis has been completed
- Condition monitoring and operational assessments are in progress

- Three tubes in steam generator 21; R2C84, R2C88 and R3C87, which had no eddy current indications reported during the inspection program, were selected for a U-bend flaw detectability study. This study involved use of insitu test equipment to pressurize the tubes to 2841 psi and 5173 psi with intermediate eddy current inspections with the 800 kHz +Point probe. No indications were detected during testing after pressurization.

An Appendix K checklist is attached as Appendix 1. The checklist addresses actions described as "Outage Considerations" in Appendix K resulting from leakage in steam generator 24, R2C5. Additional details, beyond those provided in the compliance summaries, are found in the Indian Point Unit 2 Root Cause Evaluation for steam generator 24, R2C5 Leakage Event report and in the Condition Monitoring and Operational Assessments for 2R14.

Corrective actions necessary beyond the current outage, defined as "Long Term Considerations" in Appendix K, are being addressed. Results will be finalized after the conclusion of the 2R14 steam generator inspection and repair program.

Appendix 1

Indian Point 2
EPRI PWR Steam Generator Guidelines
Appendix K Checklist
2R14 Spring 2000 Outage

Section	Compliance Summary
K.4.2.1 Result of Known Degradation	
Was the leakage due to a degradation mechanism known to exist previously?	The leak was due to primary water stress corrosion cracking (PWSCC) at the apex of the R2C5 U-bend in steam generator 24. This conclusion is based on review of the prior eddy current inspection data, prior industry experience and predictions of the tube stress that show the maximum stresses consistent with ID cracking at the tube extrados. PWSCC of row 2 U-bends was first discovered at Indian Point 2 during 2R13 when one row 2 tube, R2C67 was plugged.
K.4.2.2 Growth Rates	
What actions were taken to identify whether leakage was due to increased growth rates?	During the 2R14 steam generator inspection following the R2C5 leak event, a total of seven additional row 2 U-bends were found to contain axial indications. These include R2C87 in SG 21; R2C85 in SG 23; and R2C4, R2C69, R2C71, R2C72 and R2C74 in SG 24. In order to determine an apparent growth rate, profiles from those indications which could be resolved in the 1997 eddy current data were compared with the 2000 results. No rotating +Point examinations were performed on the low row U-bends at Indian Point 2 prior to 1997.
What were the conclusions?	Review of the indications identified in 2000, including R2C5, showed an approximate growth rate of 15 to 20% over the last operating cycle. This level of growth is typical of a PWSCC mode of degradation.
Is the leaking tube indicative of increased growth of similar degradation in the other steam generators?	Observations during the investigation indicate increased growth is not an issue. Visual inspection of R2C5 showed that crack extension was due to coalescence of two or more cracks separated by ligaments. The expected total leakage prior to tearing of any ligaments would be the sum of several small leaks. As ligaments between separate cracks began to tear, the combined cracks led to larger leaks due to the sudden increase in crack opening area. Additional discussion of apparent growth rates associated with U-bend indications will be provided in the Conditional Monitoring and Operational Assessments.
K.4.2.2.1 Previous Inspection	
What actions were taken to evaluate the effectiveness of the previous	All records and results from the 2R13 +Point inspections of row 2 and 3 U-bends were reviewed. It

inspection?	was observed that background noise and extraneous signals associated with geometric effects and deposits tended to mask the signal in R2C5. These high noise levels reduced the effectiveness of the previous inspections. Several experienced data analysts and industry experts representing Con Edison, INPO and EPRI confirmed this observation. With the benefit of hindsight, retrospective analysis of the 1997 data revealed an anomaly which, on further investigation, appears to be a signal related to the flaw that leaked. One additional indication, not reported in the 2R13 inspection, was found in R2C69 during the Con Edison review of the 1997 results.
Is the probe adequate for the area of concern?	A Zetec rotating mag bias U-bend midrange +Point probe, M/+PT-620-MRPC/FH-52PH, was used for the 2R13 U-bend inspections at Indian Point 2. When the probe was applied again in 2R14, background noise and extraneous signals associated with geometric effects and deposits were again observed in a large number of row 2 and row 3 tubes. Based on recommendations from industry experts, a Zetec rotating 800 kHz, high frequency +Point, +PT-620-MRPC/FHPH-52PH (775), was used as the probe of record for all row 2 and 3 U-bend examinations in 2R14. This high frequency probe was also used for row 4 examinations when the results from the midrange probe could not be interpreted due to noise. Use of the high frequency +Point probe in the high noise locations is an improvement over the midrange +Point probe, and has proven to be adequate probe.
Does the probe have an adequate threshold of detection?	For the 2R14 inspections, the conventional midrange +Point low row U-bend examinations were supplemented with a high frequency, 800 kHz +Point probe. The midrange tests identified U-bend indications in three tubes; R2C87 in SG 21, and R2C69 and R2C72 in SG-24. The row 2 and row 3 tubes in all steam generators were re-tested using the high frequency probe. The use of the high frequency probe proved successful in mitigating the effects of the data noise, and the improved detection resulted in the identification of four additional indications in the row 2 tubes. These include R2C85 in SG 23; and R2C4, R2C71, and R2C74 in SG 24. Midrange probe results on these four tubes were classified as "not interpretable due to bad data."
If flaw sizing was used, does the probe have adequate sizing ability?	Flaw sizing was not applied for U-bend degradation. A "plug on detection" criterion was applied for degradation detected in the U-bend areas.
Was the inspection sample size adequate?	The inspection sample size for the 2R13 inspection program included all of the active row 2 and 3 U-

	bends in all steam generators.
Were there errors in the data acquisition process?	The review of the 2R13 inspection program indicated no issues with the acquisition process.
Was the probe axial position correct?	Review of the results from the 2R13 inspection program indicated that the probe axial positioning was correct.
Was the probe in the correct tube?	Review of the results from the 2R13 inspection program indicated that the probe was in the correct tube.
Did the inspection process (probe, analysis, software and analyst) have an adequate POD?	All records and results from the 2R13 +Point inspections of row 2 and 3 U-bends were reviewed. It was observed that background noise and extraneous signals associated with geometric effects and deposits tended to mask the signal in R2C5. Thus, in hindsight we saw that data quality negatively impacted the system POD
Was the performance by the primary inspection vendor adequate?	The performance of the primary inspection vendor was adequate.
Was the performance by the secondary inspection vendor adequate?	The performance of the secondary inspection vendor was adequate.
Was the resolution process acceptable?	The performance of the resolution process was adequate.
Is the inspection interval too long?	Inspection interval duration will be evaluated through the condition monitoring and operational assessments. An operational assessment is being performed for the next operating cycle. The intent of the operational assessment is to provide reasonable assurance that the tube integrity performance criteria will be met through the period until the next scheduled tube inspection. This assessment is based on inspection results, tube repair criteria and the time interval prior to the next scheduled tube inspection. Corrective actions will be assessed, as necessary, to assure the performance criteria are met. Corrective actions could include inspecting the steam generators at more frequent intervals.
What is the industry experience with this degradation?	U-bend related leakage has occurred in two forms. One involves a rapid increase in leak rate and the other a very controlled leak occurring at a low level and increasing over a relatively long period of time. A more detailed history is provided in the root cause report.
K 4.2.3 Result of Newly Discovered Degradation	
Was the leakage due to a degradation mechanism which had not been discovered in previous outages?	PWSCC of row 2 U-bend was first discovered at Indian Point 2 during 2R13 when one row 2 tube, R2C67, was plugged.
K.5.1 Tube Leak Location Determination	
What actions were taken to identify the leaking tube?	Identification of the leaking tube was accomplished by flooding the secondary side of steam generator 24

	while conducting a remote visual examination in both the hot and cold leg channelheads. At a water level of approximately 69% of the wide range level sensor, equivalent to about 16 inches above the top of TSP6, a steady stream of water was observed to be leaking from both the hot and cold leg ends of tube R2C5. The SG fill was continued to a level of 75% of the wide range level sensor, or approximately 75 inches above the top of TSP6, an elevation that is approximately 1 foot above the apex of the outer row of tubes in the tube bundle. No leakage was observed from any other tubes during the SG fill. Additional details have been included in the root cause report.
K.5.2 Flaw Evaluation	
What eddy current techniques were applied to characterize the degradation?	Additional testing and evaluations of the leaking tube were performed to characterize the flaw. The tube was re-tested using a bobbin probe, which confirmed the length of the crack and its location at the apex of the tube. +Point testing was attempted to establish the length of the crack and verify its position. The crack opening interfered with probe rotation when testing was attempted from the cold leg. A restriction at TSP5 prevented a test from the hot leg. The short data segment from the cold leg confirmed the crack to be at the extrados of the tube. Subsequently, a +Point probe with the tracking shoe fixed in place was used successfully. This test confirmed the length of the crack at about 2.44 inches, approximately centered at the apex of the U-bend.
What additional NDE techniques were used to characterize the degradation?	**Primary Side Visual Examination** Visual examination of R2C5 was performed by inserting a Welch-Alyn fiberscope into the tube from the cold leg to beyond the apex of the U-bend. A crack was located approximately at the apex of the U-bend. The length of the crack was estimated at 2.5 inches tip-to-tip by marking the lead of the probe at the tube end when the crack was first visible and at the point when the crack was no longer visible. Key characteristics apparent from the visual examination: • The crack is principally axially oriented. Photographs of the crack seem to indicate an oblique component to the crack, that is, the crack appears to be "dog-legged"; however, it is not possible to determine conclusively that this is the case. • The crack appears to be the coalescence of several cracks that were separated by ligaments. This pattern of corrosion cracks

	results from crack initiation as short microcracks that grow to coalesce and form longer macrocracks. It is postulated that the ligaments separating the individual cracks failed, causing a "zipper-like" effect and rupture of additional ligaments. • The scaled maximum crack opening width is 2% of the tip-to-tip length of the crack, or about 50 mils. **Secondary Side Visual Inspections** Visual inspections of R2C5 and TSP 6 were conducted from the secondary side. The objectives of the inspection were to confirm the location, orientation and length of the crack and to measure the extent of hourglassing that might be present at the TSP 6 flow slots. Two-inch diameter inspection ports were installed in SG21 and SG24 at an elevation between the intrados of the Row 1 tubes and the top of TSP6, aligned with the flow slots in the TSP. Similar ports already existed on SGs 22 and 23. Inspections were performed using a fiberscope. Flowslot hourglassing at the vicinity of R2C5 was observed to be approximately 0.47 inch. Measurements of the flow slot conditions were successful, however attempts at verification of the crack properties were not. Although the probe was inserted into the space between the Column 6 and Column 7 tubes to view the apex of R2C5, the crack was not discernible in the video images of the side of Column 5. It was confirmed that the space between the R2C5 tube and the R3C5 tube was unobstructed.
Were the following data collected? Elevation and radial location; depth, length and volts; ID or OD; orientation.	Further analysis of the 1997 data for R2C5 indicated that the flaw initiated at the ID of the tube, was approximately 2.4 inches in length, located at the extrados of the tube and approximately centered at the apex. Based on a depth profile developed from the 1997 data, the average depth of the flaw was estimated between 63 and 71% and the maximum depth of the flaw about 92%. Additional testing with the bobbin probe confirmed the length of the crack and its location at the u-bend apex. +Point testing was attempted to establish the length of the crack and verify its position. The crack opening interfered with probe rotation when testing was attempted from the hot leg. A restriction at TSP5 prevented a test from the hot leg. Subsequently, a +Point probe with the tracking shoe fixed in place was used to successfully inspect the area of interest. This test confirmed the length of the crack at about 2.44 inches, approximately centered at the apex of the U-bend.

	Voltage information was not useful because the surface-riding feature of the probe was overridden to accomplish the test.
K.5.3.1 Determination of Susceptible Population	
What actions were taken to determine the susceptible population?	The susceptible population was determined by industry experience with U-bend cracking and eddy current inspection of the row 2 tubes. As outlined in EPRI Rev. 5, a critical zone and a buffer zone must be identified to address the susceptible population. For the case of the R2C5 event, all row 2 U-bends were identified as the susceptible population and row 3 U-bends were identified as the buffer zone. Row 4 U-bends were added to add conservatism to the inspection program.
Were plant-specific and industry data taken into consideration?	U-Bend related leakage has occurred in two forms. The first involves a rapid increase in leak rate and the other a very controlled leak occurring at a low level and increasing over a relatively long period of time. The rapid leakage event is characterized by the Surry 2, row 1 U-Bend tube rupture event in 1976. The source of the leak was attributed to high stresses from dent-related hourglassing of the top TSP flow slots and the resultant strain placed on the U-bend. PWSCC occurred at both the extrados and intrados of the U-bend. The leak occurred at the tube extrados. A second example of large leakage is a leak in a row 1 U-bend at Doel Unit 2 which occurred in 1979. The leaking crack was characterized as a "relatively long axial crack". Ovalization of the tube was identified as the cause of the cracking. The slowly progressing U-bend leakage is typified by the degradation observed at the Trojan power plant. In this case, the row 1 stress corrosion cracking occurred at the tangent point on one side of the U-bend. This tangent point was irregular, as a result of the bending process and apparently, high residual stresses in the irregular geometry, contributed to the onset of PWSCC. Although both types of U-bend cracking have been most aggressive in row 1, instances of tangent point cracking have also been observed in row 2. The bending process changed for row 3 and the irregular transition is no longer present. Eddy current examinations have been the principal means of following degradation at the U-bend and there have been no recent tube pulls allowing the correlation of NDE and actual tube degradation.
Did the review include tube material properties, unusual conditions, plant operating data, etc.?	Visual inspections of the secondary side were performed to measure the presence and extent of hourglassing of the TSP 6 flow slots. It has been

	documented in industry literature that the bending of U-bends results in ovalization of the tube cross-section. The degree of ovalization depends on the specific bending process utilized for the low row u-bends. The U-bends for Indian Point 2 were manufactured by Huntington Alloys. Manufacturing records are not currently available to define the bending process or the resulting ovalization. However, we will continue to pursue the recovery of this original manufacturing data. Ovalization data for similar U-bends manufactured by Huntington are available from examination of U-bends removed from the Turkey Point 4 SGs in 1976. The average ovalization at the U-bend apex of the tubes removed is: R1 - 13.9% (10 tubes), R2 - 10.0% (12 tubes), R3 – 5.0% (1 tube). This data highlights the expected reduction in tube ovality with increasing row number and associated increasing bend radius. This reduction in ovality for the higher numbered rows significantly increases the time to cracking for the higher row numbers.
K 5.3.2 Review of Previous NDE Inspection Data	
Were previous eddy current data reviewed to determine if an indication previously existed?	Subsequent to the identification of R2C5 in steam generator 24 as the tube responsible for the leakage event, a re-review was conducted of the 1997 eddy current data for that tube. With hindsight this re-analysis revealed an anomaly in the data that, upon further investigation, proved to be an indication of the flaw that developed into the leak. However, background noise was apparent on the +Point C-scan plot due to tube geometry and the presence of deposits. The noise levels would not typically permit the signal to be identified as an indication. This conclusion was consistent with that reached in the 1997 interpretation of the data. The R2C5 data from the 1997 inspection was also reviewed by several experienced, qualified data analysts and industry experts representing Westinghouse, Con Edison and EPRI who agreed with this conclusion.
Were data reviewed from tubes which were not leaking?	The re-review of 1997 eddy current results was extended to +Point data from all row 2 and 3 U-bends in all four steam generators. One additional indication, not reported in the 1997 inspection, was found. The indication, typical of PWSCC on the extrados at the tube apex, was reported in R2C69. This particular indication was not reported in 1997.
Were analysis guidelines reviewed in light of these findings?	The analysis guidelines for the low row U-bend program were reviewed in response to the R2C5 leakage event.
Were any changes made to the	Subsequent review of the 1997 R2C5 data resulted in

analysis guidelines in response to these findings?	a number of changes to the analysis process to improve the capability to identify the form of degradation responsible for the leakage. All primary, secondary and resolution analysts received training on the following changes, incorporated into the analysis guidelines as a training supplement for the 2000 U-bend inspection program: • More stringent criteria were established for data quality • The analysis setup process was changed to achieve better resolution of the 20% ID calibration notch • Supplementary instructions were developed for use of information available in the eddy current strip chart displays to assist in identification of degradation of the low row U-bends When the supplementary criteria were applied, two additional indications were detected during the 2000 inspection program. The two indications, typical of PWSCC, were found on the extrados at the tube apex, in R2C72 of steam generator 24 and in R2C89 of steam generator 21. Even with the enhancements to the analysis guidelines, background noise and extraneous signals associated with geometric effects and deposits resulted in a number of tubes being classified as difficult to interpret. During the 2000 inspections, the conventional +Point low row U-bend examinations were supplemented with a high frequency, 800 kHz +Point probe. The higher frequency probe is less susceptible to the effects of deposits. The row 2 and row 3 tubes in all steam generators were re-tested using the high frequency probe. The use of the high frequency probe proved successful in mitigating the effects of the data noise, and the improved detection resulted in the identification of four additional indications in the row 2 tubes.
Any additional training of analysts resulting from these findings?	All analysts performing analysis of data from the low row U-bend inspection program received additional training.
K 5.3.3 Review of Previous Engineering Analysis	
Were any previous growth rate predictions evaluated?	Previous growth rates have been evaluated based on Indian Point 2 specific data from the 1997 and 2000 inspections of the U-bend regions. A detailed analysis will be provided in the Condition Monitoring and Operational Assessments.
Were prior data on mechanical properties, metallurgical properties, chemistry conditions, stress conditions	Mill-annealed Alloy 600 is known to be susceptible to PWSCC under conditions where contributions from residual stresses associated with deformation are

analyzed?	present. Analyses are in progress to evaluate the sensitivity of the tube stresses to pinching of the straight legs resulting from hourglassing of the flow slots. The first analysis assumes no residual stresses from the bending process, the second seeks to establish the residual stress condition due to bending and ovalization on the tubes, prior to imposing various leg spacing boundary conditions.
How did these evaluations weigh on determination of the susceptible population, EOC leak rates, NDE results, etc?	It has been documented in industry literature that the forming of U-bends results in ovalization of the tube cross- section. The degree of ovalization depends on the specific bending process. The U-bends for Indian Point 2 were manufactured by Huntington Alloys. Plant-specific manufacturing records are not currently available. However, we will continue to pursue the recovery of this original manufacturing data. Ovalization data for similar U-bends manufactured by Huntington Alloys are available from examination of U-bends removed from the Turkey Point 4 steam generators in 1976. The average ovalization at the U-bend apex of the tubes removed is: R1=13.9% (10 tubes), R2=10.0% (12 tubes), and R3=5.0% (1 tube). These data demonstrate the expected reduction in tube ovality with increasing row number and associated increasing bend radius. This reduction in ovality for the higher numbered rows significantly increases the time to cracking for the higher row numbers.
K 5.4.1.1 ECT Scope Issues	
Were tubes adjacent to the leaking tube inspected to determine if physical damage has occurred?	All row 2, 3 and 4 U-bends were examined using a rotating +Point coil during 2R14. No damage was reported in accessible tubes adjacent to R2C5. Visual examinations from the secondary side confirm this finding. All row 1 U-bends were plugged prior to steam generator operation.
Have all susceptible tubes been identified and inspected, and what is the basis for this determination?	Active row 2 U-bends in all four steam generators were defined as a C-A in accordance with paragraph 3.6.2 of the EPRI PWR Steam Generator NDE Guidelines. Active row 3 tubes in all four steam generators were defined as the buffer zone and active row 4 tubes in all steam generators were added to the U-bend +Point inspection program for conservatism.
Are the inspection methods utilized capable of reliably detecting the degradation mechanism(s) of interest?	For the 2R14 inspections, the conventional midrange +Point low row U-bend examinations were supplemented with a high frequency, 800 kHz +Point probe. The midrange tests identified U-bend indications in three tubes; R2C87 in SG 21, and R2C69 and R2C72 in SG-24. The row 2 and row 3 tubes in all steam generators were re-tested using the high frequency probe. The use of the high frequency

	probe proved successful in mitigating the effects of the data noise, and the improved detection resulted in the identification of four additional indications in the row 2 tubes. These include R2C85 in SG 23; and R2C4, R2C71, and R2C74 in SG 24. Midrange probe results from these four tubes were classified as "not interpretable due to bad data."
K 5.4.1.2 Other NDE	
What alternative NDE methods were applied?	Alternate techniques applied during the initial investigation of the leaking tube included visual examinations for the primary and secondary side. For the 2R14 inspections, the conventional midrange +Point low row U-bend examinations were supplemented with a high frequency, 800 kHz +Point probe.
On what bases were these techniques selected?	The supplemental inspections were selected in order to provide additional data to support tube integrity assessments and to allow for better eddy current data quality, thereby enhancing resolution of PWSCC in the low row U-bends.
What additional data were collected to support tube integrity assessments?	Additional data taken to support tube integrity assessments included measurements of flow slot conditions, verification of crack characteristics and in-situ pressure testing of all U-bends where eddy current indications were reported during 2R14. Three tubes in SG 21; R2C84, R2C88 and R3C87, which had no eddy current indications reported during the inspection program, were selected for a U-bend flaw detectability study. This study involved pressurizing the tubes to 2841 psi and 5173 psi with intermediate eddy current inspections with the 800 kHz +Point probe. No indications were detected during testing after pressurization.
K 5.4.1.3 SG NDE Program Modifications	
Has an evaluation of the plant's inspection program been conducted to ensure the inspection(s) meet required criteria?	An evaluation of the Indian Point Unit 2 low row U-bend inspection program revealed background noise and extraneous signals in a large number of tubes inspected with the Zetec midrange +Point probe. For the 2R14 inspections, the midrange +Point examinations were supplemented with a high frequency, 800 kHz +Point probe.
Were any deficiencies identified in the techniques, probes, analysis procedures, vendors or training and testing programs?	A Zetec rotating mag bias U-bend midrange +Point probe, M/+PT-620-MRPC/FH-52PH, was used for the 2R13 U-bend inspections at Indian Point 2. Noise and extraneous signals associated with geometric effects and deposits in a large number of tubes complicated the analysis process. The Zetec rotating 800 kHz, high frequency +Point, +PT-620-MRPC/FHPH-52PH (775), was used as the probe of record for all row 2 and 3 U-bend examinations in

	2R14. The high frequency probe was also used for row 4 examinations when the results from the midrange probe could not be interpreted due to noise. The assessment also pointed out the need for more descriptive criteria for data quality which were defined in a training supplement. All analysts performing U-bend data analysis were trained in the new criteria.
Did the evaluation take into account experience from plants with similar degradation experience?	Application of the rotating +Point U-bend coil is the technique commonly applied for examination of low row U-bends in recirculating steam generators.
K 5.4.2.1 Structural Integrity	
Were evaluations of growth rates conducted as part of the RG 1.121 analysis for determination of safe operating intervals?	Condition monitoring and operational assessments are required to evaluate the last operating cycle and determine the next operating interval relative to the performance criteria. Inspection results, growth rate projections, PODs, detection thresholds, and technique uncertainties must all be factored into determination of a safe operating interval. Results of these evaluations will be documented in the condition monitoring and operational assessment.
If no plant-specific growth rate information is available, were industry data for the same damage type used?	Indian Point 2 specific growth rates were used to support the next operating cycle interval.
Were tube pulls considered?	The additional information that would be available from the removal of U-bends was evaluated against the effort required for implementation. Based upon industry experience, the failure of R2C5 is not a new failure mechanism. Therefore, tube removal was not deemed necessary to determine the root cause. The benefit of a tube pull is related to eddy current detection issues. The only plausible approach for removal of these U-bends is to install a 6 to 8 inch penetration involving weld build-up and subsequent stress relief. Current thoughts are that a laboratory program to address eddy current detection and sizing issues would be more appropriate than removing U-bends.
Was in-situ testing considered?	During the course of the 2R14 inspection a total of seven additional row 2 U-bends were found to contain cracks. These include R2C87 in SG 21; R2C85 in SG 23, and R2C4, R2C69, R2C71, R2C72 and R2C74 in SG 24. All seven tubes were subject to in-situ testing. Results are included in the Condition Monitoring and Operational Assessment.
K 5.4.2.2 Pressure Tests	
Were pressure tests considered?	During the course of the 2R14 inspection a total of seven additional row 2 U-bends were found to contain cracks. These include R2C87 in SG 21; R2C85 in SG 23, and R2C4, R2C69, R2C71, R2C72 and R2C74 in SG 24. All seven tubes were subject to in-situ testing.

	Results are included in the Condition Monitoring and Operational Assessment.
K 5.4.2.3 Alternate Repair Criteria	
If an ARC is used, leakage must be evaluated against the appropriate database and leakage correlation supporting the ARC.	Alternate repair criteria are not applied for U-bend cracking.
K 5.4.2.4 Adequacy of Leak Limits	
Leakage limits should be evaluated to ensure acceptability following the leaker outage.	An assessment of plant leakage limits is being conducted using the guidance provided in EPRI Report TR-104788, "PWR Primary-to-Secondary Leak Guidelines". Considering the factors contributing to the R2C5 leakage, it is unlikely that enhanced leak limits would have reduced the probability of this event. However, primary to secondary leakage limits will be reviewed.
5.4.3 Tube Pulls	
Were tube pulls considered?	Current thinking is that a laboratory program to address eddy current detection and sizing issues is more appropriate than attempting to remove U-bends.
5.4.4 Root Cause	
Was a root cause analysis conducted?	A root cause evaluation was conducted. Results are summarized in a report describing the technical investigation of the primary-to-secondary leakage event. The report identifies the mechanism by which the leakage occurred, based on 1) the examination of the SG performed after the plant achieved cold shutdown, 2) a review of the operating experience of Indian Point 2, and 3) a review of previous industry experience. An action plan and information to initiate mitigation activities are also described in this report.
5.4.5 Repair	
What was the repair strategy?	Row 2 tubes in all steam generators are scheduled for repair by plugging, irrespective of whether indications of degradation are present or not. There were no indications of degradation in any of the row 3 or 4 U-bends.
5.4.6 Cycle Length/Operating Interval	
Are results from evaluations of structural and leakage compliance with specific margins being used to assess the acceptable operating interval?	Condition monitoring and operational assessments are being prepared in accordance with NEI 97-06. The condition monitoring assessment will evaluate the eddy current results against the structural and leakage limits identified in the degradation assessment. The purpose of this assessment is to demonstrate whether adequate tube integrity has been maintained since the last inspection. This assessment will consider the eddy current results as well as results of any in situ testing performed during the outage for the most limiting indications. Should condition monitoring reveal one or more tubes that fail

	to meet the performance criteria, programmatic deficiencies may exist and shall be assessed. The operational assessment provides reasonable assurance that the tube integrity performance criteria will be met through the period until the next scheduled tube inspection. This assessment is based on inspection results, tube repair criteria and the time interval prior to the next scheduled tube inspection. Corrective actions will be assessed, as necessary, to assure the performance criteria are met. Corrective actions could include inspecting the steam generators at more frequent intervals.