Indian Point 2 - February 15, 2000
SG Tube Failure
Commissioners' TA Briefing
August 24, 2000

A/169

- Introduction - Brian Holian, Deputy Division Director, DRS, Region I
- Special Steam Generator Team Inspection - Wayne Schmidt, Team Leader, DRS, Region I
- Risk Analysis - Steve Long, Senior Risk Analyst, DSSA, NRR
- Steam Generator Regulator Issue Summary - Ted Sullivan, Section Chief, DE, NRR

Introduction:

- Discussion of the February 15, 2000, event.
  - MD 8.3 - AIT focused on review of Con Edison's response.
    - Initial "Event Risk" Assessment (Conditional Core Damage Probability (CCDP))
    - Event cause not reviewed by AIT
- SG Special Inspection exited July 20, 2000.
    - Con Edison disagreed with the findings and provided some additional information.
  - Team's preliminary findings issued July 27, 2000.
  - Report in final Regional and NRR review (to be issued the week of 8/28).
    - Communication Plan
- SDP "Condition Risk" (Change in Core Damage Frequency (delta-CDF))
- Agency Focus Meeting 9/11 and SG Regulatory Conference 9/26.

Steam Generator Special Inspection:

- Reason for the Inspection
- Team Composition
- Inspection Phases
- General Background (SG specifics and history, technical specifications)
- Inspection Results
  - Performance Issues and Inspection Findings
- Con Edison Disagreements with Inspection Findings

Team Composition

Integrated NRC effort. Substantial coordination and cooperation between NRR and Region I in planning, conducting, and assessing findings.

- Inspection Support and Team Leader -Region I
- Engineering and Part Time Eddy Current Support -NRR
- Program Review Contractor Support -NRR
- Finding Characterization - Region I and NRR
- Significance Determination Process -NRR and Region I

Inspection Phases:

Broken up into several phases:

- Initial NRR engineering and contractor support to gather information and review the beginning of the 2000 outage.
- Assessment of 1997 Outage Performance
  - Steam Generator Visual and Eddy Current Inspection
  - Eddy Current Inspection Program
- Significance Determination Process - Assessing the potential risk of the findings.

Background:

IP 2 Steam Generators

- Model 44 SGs - no chemical cleaning done.
- 3,260 tubes - 92 in each of the low-rows (rows 1-4)
- Row 1 plugged prior to operation
- Mill-annealed Alloy 600 - 0.875-inch OD 0.05-inch wall thickness
- Six tube support plates provide horizontal stability
  - Each tube support plated has six flow slots flame cut across their diameter (between row 1 tube legs).

IP2 SG History

- Numerous degradation mechanisms prior to 1997
  - ODSCC
    - Crevice - between roll transition and the top of the tube sheet
    - Sludge pile
    - Dented areas
  - PWSCC
    - Tube roll transition
    - Dented tubes
    - None detected in U-bends
- 1997 Results
    - One PWSCC indication in the at the apex U-bend R2C67 in SG 24
    - Tube restrictions due to denting at the upper support plate
- February, 15, 2000 - tube failure
  - PWSCC at the apex of low-row U-bend (R2C5 in SG24).

Technical Specifications

- Eddy Current Testing
  - 40-percent TW defect plugging limit. (U-bend indications plugged on detection due to sizing problems.)
  - Report significant deformation of flow slots (hour-glassing). Added as a Result of Surry-2 event in 1976.
    - Hour-glassing is the deformation of the flow slots, due to corrosion, to the point that the sides are forced towards the middle, making it look like an hour-glass.
    - Hour-glassing is significant because it moves the tube legs together putting stress at the tube apex.
    - Tube denting is a precursor to hour-glassing.
- Primary to Secondary Leakage Monitoring
  - Limited to 0.3 gpm

Inspection Results:

Initial Phase - 2000 Outage

- Observed use of the mid-range Plus Point probe and reviewed some 1997 data
  - Mid-range Plus Point U-bend technique not calibrated or setup in accordance with the EPRI qualification.
    - Technique changed to be correct
  - 2000 eddy current data was very noisy.
    - Con Edison did not have criteria for when the noise could be masking data.
    - Criteria developed - approximately 450 tubes exceeded the criteria. High frequency probe developed and used. Eight tubes with defects found out of the 450.

Steam Generator Inspection Results

- Overall the team found that technical direction for the 1997 SG inspection program (eddy current and visual) was deficient in several respects. Con Ed did not address conditions that adversely affected the detection of, and increased the susceptibility to, PWSCC flaws in the low-row, small radius U-bend tubes.

- 1997 - First instance of U-bend PWSCC defect (R2C67 in SG 24).
  - Significance not understood by Con Ed.
  - Apex flaws have been associated with through wall leakage and burst.
  - There have been tube ruptures due to PWSCC at U-Bend apex (Surry -2 1976)
  - No review for the possibility of hour-glassing.
  - No entry into the corrective action program.
  - Tube plugged on detection.

- 1997 - First instance of low-row (row 2) tube denting at the upper support plate.
  - Indicated a significant potential for hour-glassing.
  - 19 tubes identified, as U-bend restrictions. The team found that these were upper support plate restrictions due to denting. The tubes were plugged in accordance with TS.
  - No procedure or specific examination criteria for significant hour-glassing.
  - No corrective action program review.

- 1997 - Significant signal "noise" interfered with the data analysis in the U-bend areas.
  - This problem was not evaluated.
  - Detailed careful review of 1997 data could have identified four defects. Included the one tube that failed (R2C5 in SG 24).
  - Con Ed did not investigate and evaluate noise in the other low-row tubes after finding the defect R2C67 in SG 24.
  - No corrective action program review.

1997 Steam Generator Program Issues

- Compared to Rev 4 of the EPRI Guidelines, technique qualification, data analysis guidelines, and analyst training reviewed.
- Con Ed did not ensure that the mid-range Plus Point used in the U-bend area was calibrated and setup in accordance with the EPRI technique -had a marginal effect on the detection of small flaws.
- Data analysis guidelines did not have any specifics on how to use the mid-range Plus Point in the U-bends.
- Training documentation was incomplete.

Inspection Findings:

- **Potential Red** - Inadequate Corrective Actions taken during 1997 outage inspection. Three significant conditions not identified and evaluated. Collectively, they decreased probability of detection of U-bend flaws and increased the probability that a defect would remain in-service.
  - First PWSCC U-bend indication not recognized for its significance. Not entered in Corrective Action System.
  - First upper TSP denting not recognized for its potential for hour-glassing and Con Edison did not have a method of ensuring that significant hour-glassing was not taking place. Not entered into Corrective Action System.
  - Eddy Current noise not evaluated and not corrected for. Not entered into Corrective Action System.

- **Green - NCV** - Mid-range Plus Point probe not properly calibrated and setup for U-bend inspections - based on EPRI guidance.
  - Would not have a significant affect on the ability to detect flaws. Con Ed corrected the issue during the 2000 exam.

- No color - Con Edison's root cause analysis did not address the performance issues identified by the team and was inadequate.

Con Edison Disagreements with Findings:

- The PWSCC indication was expected and no additional assessment was warranted after this discovery.
  - NRC Response
    - Based on SG Life Prediction PWSCC was a possibility and needed to be inspected for, but it was not clearly expected. The team believes this was a significant unrealized opportunity.
- There were no specific noise criteria relative to the probability of detection of flaws using eddy current examination in the EPRI Guidelines.
  - NRC Response
    - This is a true statement; however, the issue of noise masking signals is not new to eddy current inspection.
    - Several NRC documents discuss noise NUREG 1477 and IN 94-88.

- The root cause submitted was complete and accurate .
  - NRC Response
    - The finding stands based on the inspection results.
- The 2000 NRC Team's findings are not in agreement with NRC Team Inspection Report 50-247/97007, dated July 16, 1997.
  - NRC Response
    - The1997 inspection was not a team, it was an integrated report with the SG inspection done by one inspector. Con Edison's SG inspection was deemed adequate.
    - It was a sampling process and not to the depth of the team inspection.
    - There was no specific review of the quality of the eddy current data or the analysis of the specific results.

- All 1997 steam generator inspection requirements were met and the team had not identified any specific requirements, standards or guidelines that were not met.
  - NRC Response
    - The team identified 10 CFR 50, Appendix B, Criterion XVI Corrective Actions as a requirement that was not met.

Eddy Current Testing

- Principle
  - A coil in an alternating current circuit produces a magnetic field.
  - If a conductor is placed into this magnetic field a secondary current (eddy current) is induced in the conductor and it too generates its own magnetic field
  - The secondary current and magnetic field oppose the primary current and field
- The probe establishes the eddy current in the SG tube and the analyst detects defects in the SG tube by observing changes in the coil voltage and the phase angle between the coil voltage and current.