IP-2 SG Tube Failure Lessons-Learned Report 10/23/00
ML 003762242 (Report)
ML 00376 22 54 (Memo + Report)

8.2 NRC Oversight Process and Inspection Program

8.2.1 Background

NRC Manual Chapter 2515, "Light Water Inspection Program - Operations Phase," describes the NRC's inspection policy for the light-water operating reactor inspection program. The key objective of the program is to obtain factual information providing objective evidence that power reactor facilities are operated safely and licensee activities do not pose an undue risk to public health and safety.

The steam generator (SG) tube failure at Indian Point 2 (IP2) occurred at a time when the NRC was transitioning to a new regulatory oversight process. Effective April 2, 2000, the NRC implemented this new reactor oversight process (ROP) for all commercial nuclear power plants. Many aspects of the agency's oversight process, such as the inspection program, assessment process, and enforcement policy, were revised to make them more objective, predictable, and understandable. Additionally, several new oversight processes were developed, such as performance indicators (PIs) and a significance determination process (SDP) for inspection findings.

The new ROP uses a framework of seven cornerstones of safety as the structure and basis for all oversight activities. These cornerstones are Initiating Events, Mitigating Systems, Barrier Integrity, Emergency Preparedness, Occupational Radiation Safety, Public Radiation Safety, and Physical Protection. For each of these cornerstones, the new oversight process applies risk-informed safety thresholds to performance indicators and a baseline inspection program to obtain indications of declining licensee performance. These safety thresholds establish the Green, White, Yellow, and Red performance bands for both PIs and inspection findings.

A set of 18 PIs, with risk-informed thresholds, were developed to provide objective indications of licensee performance. The data for these PIs are collected by licensees and reported quarterly to the NRC. PI reporting is conducted in accordance with guidance document NEI 99-02, "Regulatory Assessment Performance Indicator Guideline," which was developed by the industry and reviewed and approved by the NRC. SG tube leakage is reported by the Reactor Coolant System Leakage PI under the Barrier Integrity Cornerstone.

The baseline inspection element of the ROP inspection program is to be performed at all operating reactors. The inspections are performed by the resident and region-based inspectors. In the Barrier Integrity Cornerstone, inspection procedure 71111.08, "Inservice Inspection Activities" (Reference 1), is applicable for SG tube examinations. The procedure is required to be completed once every two years during a refueling outage at each facility.

Plants whose performance falls below a certain level will receive additional plant-specific supplemental inspection. The supplemental inspections are only performed as a result of risk-significant licensee performance issues that are identified by either performance indicators (PIs), baseline inspections, or event analysis. The depth and breadth of specific supplemental inspections chosen for implementation depend upon the risk characterization of the issues.

The risk characterization of inspection findings is performed using the SDP. The SDP was

J 133

Prior to April 2000, NRC ISI inspections were performed at each facility by regional inspectors in accordance with the core inspection program. The scope of the inspector's review was based on a judgement regarding current significant issues and also as directed by the inspector's supervisor. The planning did not usually involve NRC headquarters personnel. It did not require that industry information be factored in, although it sometimes was. New industry and generic information, such as Information Notices and Generic Letters, did not always get to the regional inspectors in time to be factored into their inspection activities. The site inspection involved one inspector for a period of one week and was not necessarily limited to SG activities, but could also include non-destructive examination (NDE) activities on other components.

NRR has routinely held conference calls with each licensee during its refueling outage (outage phone calls) to assess the adequacy of the licensee's SG tube eddy current inspections. These telephone calls involved regional participation on occasion and included discussions on the results of the licensee's SG tube inspections and repair plans. NRR has a prepared outline of important discussion areas to cover with the licensee and documents the results of the conference call internally. However, this effort has not been a formal part of the inspection program, and the results are not documented in inspection reports. During the 1997 SG tube examination at IP2, NRR and Con Ed held telephone conference calls to discuss the licensee's examination activities and findings. The Task Group reviewed and discussed with NRC staff, records of the telephone calls that were held on June 2, 3, and 29, 1997. There was no indication that a row 2 tube U-bend crack, such as one that was found in tube R2C67 of SG 24, was discussed during the calls. Nevertheless, some staff members interviewed by the Task Group indicated that they had specifically asked during the phone calls if any U-bend degradation in small radius tubes had been identified. The Task Group noted that the timing of the phone calls relative to when the flaw was identified was not clear.

In the ROP, the important attributes of each cornerstone of safety are covered by the combination of PIs and inspection. One of the key attributes of the Barrier Integrity cornerstone is to monitor the condition of the SG tubes, which make up a large portion of the RCS pressure boundary. Adverse trends in primary-to-secondary leakage during power operation indicate a degradation of the SG tubes, and may warrant an increased level of NRC interaction with the licensee. Under the baseline inspection program, SG tube leakage during plant operation could be routinely monitored by the inspectors by IMC 2515, Appendix D, "Plant Status." Although primary-to-secondary SG leakage is not specifically noted, this manual chapter does direct inspectors to periodically walkdown the control room to note any adverse plant parameter trends, and to review various logs such as the control room and chemistry logs. However, risk-informed thresholds have not been established in the ROP that define when an adverse trend in primary-to-secondary leakage has reached a point where increased NRC interaction is warranted.

Primary-to-secondary leakage is also captured by the Reactor Coolant System (RCS) leakage Performance Indicator (PI). This PI tracks identified RCS leakage, which is generally on the order of gallons per minute. Steam generator tube leakage is generally on the order of gallons per day, and therefore adverse trends in primary-to-secondary leakage from SGs would not be readily apparent in this PI.

The industry guidance for reporting the RCS leakage PI, as contained in NEI 99-02, states that

although SG tubes are listed in the inspection guidance.

IP 71111.08, Inservice Inspection Activities, does not specifically require that SG examinations be inspected. Even if inspected, the review could be minimal. The same was true under the old core program and IP 73753, and is not unique to the ROP and IP 71111.08. The inspection procedure contains significantly less guidance for conduct of the inspection than the previous core inspection procedure, IP 73753. IP 50002 was available under the old inspection program to be conducted as a regional initiative focused inspection on SG condition as well as to assess the effectiveness of the licensee's SG tube examination program. This inspection procedure was retained for use in the revised reactor oversight process in the supplemental inspection program, as documented in IMC 2515, Appendix B.

indications, and plugging of defective tubes.

The NRC inspected IP2's 1997 SG Examination using IP 73753. The results were documented in NRC inspection report 50-247/97-07 (Reference 8). The Task Group discussed the 1997 inspection with the regional inspection specialist that performed the inspection. The inspector noted that he was not an eddy current specialist, but more of a general non-destructive examination inspector. Therefore, he was not skilled in evaluating eddy current data, especially in determining data quality. He also noted that he did not receive IN 97-26, "Degradation in Small-Radius U-bend Regions of Steam Generator Tubes," issued May 19, 1997, before he performed the inspection. He noted that information that would assist the inspectors is often not disseminated in a timely way to prepare the regional inspectors for upcoming inspections. This is especially important for highly specialized areas like SG inspections. The inspector also noted that he used the NRC's general ISI inspection procedure (IP 73753), and not the little-used, more specialized SG inspection procedure (IP 50002).

The NRC's 1997 inspection of Con Ed's SG tube examinations focused on the licensee's management of the SG examinations and the data collection process, and not on the analysis of the results of their examinations. For example, the NRC inspection report contained assessments such as "good management oversight," and "examinations conducted in accordance with EPRI SG Tube Inspection Guidelines." In the report, it was also noted that Con Ed expanded their examination to inspect all support plate intersections with Cecco-5 probe and full length of all tubes with bobbin coil probes and that they also used plus point probes during the examination. During the inspection, the NRC inspector spent about 25% of his time on other issues that were not related to eddy current examination. The inspector noted that IP2 had a third party, independent level III NDE person who was not a direct employee of Westinghouse or Con Ed. The NRC's onsite inspection lasted for four days. At the end of the on site inspection week, the licensee's tube examination was still ongoing. Later, on June 29, 1997, the NRC inspector participated in a telephone call involving Con Ed, NRR and the Region I office to discuss the licensee's examination results. Among the topics discussed were IP2's use of the Cecco-5 probe, and the identification of outside diameter stress corrosion cracking (ODSCC). Following the examinations, the licensee submitted the required TS examination report. There is no indication that the NRC reviewed the 1997 examination results in detail.

The Task Group observed that the NRC issued Information Notice (IN) 97-26, "Degradation in Small Radius U-bend Regions of Steam Generator Tubes," in May 1997, just before Con Ed began their 1997 SG inspection. This notice provided current information, at the time, about degradation affecting small radius (rows 1 and 2) U-bend regions of SG tubes in order to alert utilities to potential problems in this area. As with all information notices, this IN did not require any specific action or written response from licensees. However, it did point out U-bend PWSCC degradation problems in mill-annealed alloy 600 SG tubes, the same material as IP2's SG tubes. The IN stated that "[t]he susceptibility to cracking in small radius U-bends and the findings of recent field inspections have emphasized the importance of inspection of this area of SGs with techniques capable of accurately detecting U-bend degradation." Due to the timing of the release of the IN with respect to the beginning of the SG outage at IP2 in May 1997, the Task Group determined that the IN may not have been received by the licensee's SG group

The NRC staff had responded to the primary-to-secondary leakage at IP2 prior to the February 2000 SG tube failure event. While there were no specific NRC inspection procedures to address the leakage, the NRC resident inspectors brought up the leakage issue and it was followed up by both the regional and headquarters NRC staff. The staff felt that leakage was not up to the concern level but needed to be closely watched. The staff probably consulted the EPRI guidance on primary-to-secondary leakage. The leakage was considered not indicative of an imminent failure. Before the tube failed, the maximum leakage was only about 5 gpd. After the tube failed, the licensee estimated a leakage of about 48 gpm. Based on the leakage before failure, the Task Group considered that the staff's actions were appropriate. This, however, indicates inadequacies associated with the reliance on Technical Specification and EPRI leakage limits for ensuring that the plant could be shut down to avert a tube failure.

8.2.3 Conclusions/Lessons-Learned

Based on the observations discussed above, the Task Group reached the following conclusions:

1) The NRC's baseline inspection program (specifically inspection procedure 71111.08, Inservice Inspection Activities) does not include guidance on the scope and depth of NRC's inspection of licensees SG tube examinations.

2) The regional inspector training is not designed to develop inspectors' technical expertise in the area of eddy current examination. Therefore, the inspection process may not be reasonably expected to preclude a situation such as the IP2 SG tube failure from occurring.

3) The NRC (NRR) telephone calls (outage phone calls) with the licensees during the licensees' SG tube examinations can be effective, but are not formally included in either the licensing or the inspection process.

4) Relevant technical information generated by staff technical offices, that may improve the effectiveness of NRC inspections, is not being consistently considered for inclusion in the inspection program. There were delays in communicating generic information (such as Information Notice 97-26, "Degradation in Small-Radius U-bend Regions of Steam Generator Tubes," dated May 19, 1997, and NUREG/CR-6365, "Steam Generator Tube Failures," dated April 1996) to the inspector to use in the inspection process.

5) The licensee has the primary responsibility to monitor primary-to-secondary leakage during power operation and take corrective actions in response to adverse trends. However, risk-informed thresholds have not been established for either the baseline inspection program or the performance indicators (PIs) to identify those adverse trends in primary-to-secondary leakage that warrant increased NRC interaction. Also, due to differences in TS requirements between plants, the industry guidance contained in NEI 99-02 for reporting the reactor coolant system leakage PI may not ensure that primary-to-secondary SG leakage is reported in all instances by all licensees.

TABLE 9-1
TASK GROUP RECOMMENDATIONS

No.	Recommendation	Actio
1	Con Ed must correct the deficiencies in its SG tube integrity program that led to the degraded SG condition during IP2 cycle 14. Otherwise, the long-term risk of SGTR at IP2 could be affected.	Con
2	The EPRI guidelines and the licensees implementation of the guidelines should be improved based on lessons-learned from the IP2 experience. Specific recommendations are listed below as items 2(a) through 2(o).	
2a	Industry should update the EPRI SG Examination Guidelines to incorporate data quality criteria. Guidelines should explicitly discuss how to identify excessive noise in the data, how to identify the source of the noise, and what to do about the noise after the source is identified.	Indu EP
2b	Industry should consider the issue of noise in newer tubes in the revision to the EPRI SG examination guidelines.	Indu EP
2c	The EPRI guidelines should address the use of noise minimization techniques such as filtering algorithms.	Indu EP
2d	Licensees should review generic industry guidelines carefully to ensure that the conditions/assumptions supporting the guidelines apply to their plant-specific situation (for example, site-specific performance demonstrations for examination techniques).	Indu EP
2e	Industry should update the EPRI SG Examination Guidelines to incorporate guidance on how to evaluate flow slots for hour-glassing and the impact of hour-glassing on PWSCC in low row U-bends.	Indu EP
2f	The licensee and NRC staff should agree on a measurable definition of "significant" for hour-glassing.	Indu NR
2g	Site validation of techniques should be used for each detection technique, focusing on the most challenging areas of degradation.	Indu EP
2h	Licensees should use a conservative approach to screening tubes for in-situ testing, and should include tubes with new forms of degradation even if the screening threshold is not met. Industry should modify guidelines on the screening criteria to include new forms of degradation.	Indu EP
2i	Industry guidelines should caution licensees not to rely heavily on assessments based on sizing techniques that are not qualified.	Indu EP
2j	Licensees should consider the effect of the threshold of detection and sizing accuracy on the growth rate assumptions.	Indu EP
2k	Industry should update the EPRI SG Examination Guidelines to incorporate guidelines on prudent measures to be followed when evaluating the first occurrence of a new type of degradation for SG tubes.	Indu EP

TABLE 9-1
TASK GROUP RECOMMENDATIONS

2l	Licensees should recognize the potential for new forms of degradation and use robust techniques to look for problems that may exist, and not focus solely on degradation that has been found in the past. When a new type of SG tube degradation occurs for the first time, licensees should determine the implications on SG condition monitoring and operational assessment (e.g., potential for the tube to rupture before leaking, such as at the apex of a small radius U-bend).	Indu EF
2m	The EPRI Steam Generator Integrity Assessment Guidelines should be revised to address that care should be taken in relying on predictive models for PWSCC, and that licensees should maintain an aggressive approach in evaluating inconsistencies with predicted and observed SG degradation behavior.	Indu EF
2n	In addition to using two human analysts for the primary and secondary analysts, industry should consider developing guidelines for using computers to screen the test data.	Indu EF
2o	The Task Group notes that its recommendations on eddy current testing and tube inspection guidelines were focused on a particular situation that existed at IP2 (i.e., a specific type of degradation and location within the SG). While incorporation of the IP2 lessons into industry guidelines is important, further development of industry guidelines should also address all SG tube degradation modes and degradation locations in order to be generally applicable.	Indu EF
3	The PWR TSs should be improved based on lessons-learned from the IP2 experience. Specific recommendations are listed below as items 3(a) and 3(b).	
3a	PWR TSs (or the regulatory framework currently being developed via the industry initiative) should ensure the technical requirements are strengthened to reflect the current knowledge of the SG degradation mechanisms, examination techniques, and methodology.	Indu NI
3b	The industry should assess the adequacy of the TS regarding operational leakage limits.	Indu NI
4	The NEI 97-06 initiative should be improved based on lessons-learned from the IP2 experience. Specific recommendations are listed below as items 4(a) through 4(c).	
4a	The licensees should ensure that contractors supporting the SG examination perform in an acceptable manner. The industry initiative should provide reasonable assurance of contractor oversight by licensees.	Indu NI
4b	In the near term, industry should ensure that lessons-learned from the IP2 experience are being used to ensure that effective SG tube integrity programs are being implemented by licensees. NEI should provide feedback to the NRC on the status of licensee implementation of IP2 lessons-learned.	Indu NI
4c	In the longer term, industry should also use lessons-learned from the IP2 experience to strengthen the NEI initiative. NEI should provide feedback to the NRC on the specific changes planned to the 97-06 initiative based on the IP2 experience, including a schedule for implementation of the changes.	Indu NI
5	Over the long-term, the NRC should improve the oversight of licensee SG tube integrity programs based on the generic character of some of the lessons-learned from the IP2 experience. In addition, improvements should be made to the inspection process. Specific recommendations are listed below as items 5(a) through 5(g).	NF
5a	The staff should develop additional guidance on when and how much of its inspection of licensees' SG tube examination should be completed in the NRC baseline inspection program.	NF

8.2.4 (1)

TABLE 9-1
TASK GROUP RECOMMENDATIONS

8.2.4 (2)	5b	The staff should review the training requirements for NRC inspectors for the SG baseline inspection program. The review should include the guidance contained in the SG inspection procedure to determine the required training for NRC inspectors to successfully complete the objectives of the NRC inspection program.	NR
	5c	The NRC should take steps to ensure that SG expertise is available to support the objective of the NRC's licensing and inspection programs. This could be done through formal training and/or transferring knowledge from in-house SG experts to other staff through written guidance documents or a mentoring program.	NR
8.2.4 (3)	5d	The technical interaction between the licensees and NRR (outage phone calls) during the licensees' SG tube examinations can be effective and should be factored into the inspection program. The phone calls should involve the regional inspectors and should be used as part of the preparation for NRC inspections. This will afford NRR the opportunity to help focus the inspections on the appropriate issues.	NR
8.2.4 (5)	5e	The staff should assess how the baseline inspection program and/or performance indicators (PIs) could be revised to adequately identify adverse trends in primary-to-secondary leakage during power operation, which could indicate a degradation of the SG tube integrity. The staff should ensure that any PI reporting requirements for primary-to-secondary leakage take into account potential differences in license requirements to ensure that all licensees would be required to report primary-to-secondary leakage for both normal and failed SG conditions.	NR
8.2.4 (6)	5f	The staff should establish risk-informed thresholds, either through the PIs or the significance determination process (SDP), that can be applied to the results of the periodic SG inspections to identify SG tube degradation that warrants increased NRC attention.	NR
8.2.4 (4)	5g	The staff should develop, revise, and implement, as appropriate, the process for timely dissemination of technical information to the inspectors to ensure that relevant technical information is reviewed and considered for inclusion in the inspection program.	NR
	6	The NRC should make improvements in the licensing review process. Specific recommendations are listed below as items 6(a) through 6(e).	
	6a	The NRC staff should develop formal written guidance for technical reviewers to utilize in performing license amendment reviews related to SG tube integrity. The guidance should provide specific criteria to identify when the staff should review previous licensee SG inspection reports.	NR
	6b	The NRC staff SE's should be specific as to what information is relied on to form the basis for its conclusions (i.e., basis for approving the amendment). In addition, if the NRC staff is aware of significant information in the licensee's application that is incorrect, these issues should be discussed in the staff's SE even if the information was not relied upon to form a staff conclusion. This will help to identify those issues not otherwise addressed in the SE that later could be misinterpreted to imply that the staff concurred with the licensee's analysis/conclusions. OL No. 803 should be revised accordingly.	NR

TABLE 9-1
TASK GROUP RECOMMENDATIONS

6c	The staff should assess the need for, and the process for the staff review of, the TS required reports that document the results of licensee's SG tube examinations. If the staff determines that such reports should be required, then the staff should also determine the information to be included in such reports, and the timing for submittal of the reports to the NRC. The staff should also develop a well-defined process to review such reports, and the specific purposes and objectives of such reviews. The revised reactor oversight process, including the SDP and the telephone calls with the licensee during an outage, should be considered in the process.	NF
6d	The NRC staff should revise OL No. 803 to add a discussion regarding interface between NRR and Regional staff during SE development. The discussion should state that in limited cases it may be of value to get input from the Region (e.g., if the NRR SE relies heavily on a statement from the licensee on a risk-significant issue, NRR could request that the Region perform an inspection to verify the statement).	NF
6e	When NRR requests that RES perform an independent technical review of a staff's SE, NRR and RES should develop a process for handling the request and response.	NF
7	The NRC should assign a high priority to its review of the NEI SG initiative and the associated EPRI guidelines. The NRC should use the SECY-00-0116 process, once approved, to expedite the review of the NEI 97-06 initiative.	NF
8	In the interim, the NRC should issue a generic communication to clarify the current NRC position on industry guidance and to highlight SG tube integrity program weaknesses manifested by the IP2 experience that could exist at other plants.	NF
9	The NRC should incorporate experience gained from the IP2 event and the SDP process into planned initiatives on risk communication and outreach to the public.	NF