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UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, D.C. 20555-0001

NRC GENERIC LETTER 2004-XX: REQUIREMENTS FOR STEAM GENERATOR TUBE INSPECTIONS

Addressees

All holders of operating licenses for pressurized-water reactors (PWRs), except those who have permanently ceased operations and have certified that fuel has been permanently removed from the reactor vessel.

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this generic letter to

(1) advise addressees that the NRC's interpretation of the technical specification (TS) requirements in conjunction with 10 CFR Part 50, Appendix B, raises questions as to whether certain licensee steam generator (SG) tube inspection practices ensure compliance with these requirements,

(2) request that addressees submit a description of the tube inspections performed at their plants, including an assessment of whether these inspections ensure compliance with the TS requirements in conjunction with 10 CFR Part 50, Appendix B,

(3) request that addressees who conclude they are not in compliance with the SG tube inspection requirements contained in their TS in conjunction with 10 CFR Part 50, Appendix B, propose plans for coming into compliance with these requirements, and

(4) request addressees to submit a tube structural and leakage integrity safety assessment that addresses any differences between their practices and the NRC's position regarding the requirements of the TS in conjunction with 10 CFR Part 50, Appendix B. A safety assessment should be submitted for all areas of the tube required to be inspected by the TS, where flaws have the potential to exist and inspection techniques capable of detecting these flaws are not being used. This assessment should include an evaluation of whether the inspection practices rely on an acceptance standard different from the TS acceptance standards and whether the technical basis for these inspection practices constitutes a change to the "method of evaluation" (as defined in 10 CFR 50.59) for establishing the structural and leakage integrity of the tube-to-tubesheet joint.

Pursuant to 10 CFR 50.54(f), addressees are required to submit a written response to this generic letter.

Attachment 1

Background

Steam generator tubes function as an integral part of the reactor coolant pressure boundary (RCPB) and, in addition, serve to isolate radiological fission products in the primary coolant from the secondary coolant and the environment. For the purposes of this generic letter, tube integrity means that the tubes are capable of performing these functions in accordance with the plant design basis.

Title 10 of the *Code of Federal Regulations* (10 CFR) establishes the fundamental regulatory requirements with respect to the integrity of the SG tubing. Specifically, the general design criteria (GDC) in Appendix A to 10 CFR Part 50 state that the RCPB shall be "designed, fabricated, erected, and tested so as to have an extremely low probability of abnormal leakage, of rapidly propagating failure, and of gross rupture" (GDC 14), and "designed, fabricated, erected, and tested to the highest quality standards practical" (GDC 30), and that RCPB components shall be "designed to permit periodic inspection and testing of important areas and features to assess their structural and leaktight integrity" (GDC 32). For plants that were issued construction permits before the effective date of 10 CFR Part 50, Appendix A, the plant specific Principal Design Criteria (PDC) in the plant design basis established similar fundamental regulatory requirements pertaining to the integrity of the steam generator tubing.

Given the importance of SG tube integrity, all current PWR licensees have TS governing the surveillance of SG tubes. These TS typically do not prescribe nondestructive test methods for inspecting tubes or specify where a particular methodology should be used. For example, current TS may employ the following or similar general language:

> Tube inspection for tubes selected in accordance with Table [xxxx] means an inspection of the steam generator tube from the point of entry (hot leg side) completely around the U-bend to the top support of the cold leg, excluding sleeved areas.

Although the TS do not prescribe the use of particular nondestructive test methods, the NRC position identified in Regulatory Guide 1.83 states that "...the equipment should be capable of locating and identifying defects due to stress corrosion cracking and due to tube wall thinning by mechanical damage, chemical wastage, or other causes." In addition, the TS surveillance requirements specify acceptance limits for SG tubes (often called plugging or repair limits) to be applied to the inspection results. The surveillance requirements seek to ensure that enough information is obtained about imperfections (e.g., flaws) in the tubes to determine if TS plugging limits are being met. Tube imperfections are defined in the TS and include circumferential and axial cracks.

SG tubes are also subject to the quality assurance requirements of 10 CFR Part 50, Appendix B. Specifically, SG tubes are safety-related components, and, therefore, subject to the criteria of Appendix B. Notwithstanding that the TS do not specify nondestructive test methods or in what locations particular test methods must be employed, Criterion IX of 10 CFR Part 50, Appendix B, "Control of Special Processes," requires, in part, that nondestructive testing be controlled and accomplished by qualified personnel using qualified procedures in accordance with applicable codes, standards, specifications, criteria, and other special

requirements. In addition, Criterion XI, "Test Control," requires, in part, that test procedures shall include provisions for assuring that all prerequisites for the given test have been met, and that adequate test instrumentation is available and used. Moreover, Criterion XVI, "Corrective Action," requires, in part, that "measures shall be established to assure that conditions adverse to quality ... are promptly identified and corrected." This generic letter addresses the selection of appropriate inspection techniques for tube locations required to be inspected by plant TS, given the tubes selected for inspection based on plant TS sampling requirements, or for tube locations in which licensees have reason to believe a condition adverse to quality may be present.

Licensees currently employ an eddy current test bobbin probe, at least, to inspect the entire length of tubing required by the TS. The bobbin probe is a high-speed probe which the industry has demonstrated is capable of reliably detecting volumetric flaws and axially-oriented cracks in the absence of significant masking signals. Masking signals may be produced by tube geometry variations or irregularities along the tube axis (such as small-radius U-bends, dents and dings, and expansion transitions) or by tube surface irregularities. Masking signals can also be produced by deposits on the tube surface, adjacent support structures (such as the tubesheet), probe wobble, cold working, permeability variations, or electrical noise.

While the bobbin probe generally provides an effective means of SG tube inspection over much of the tube length, experience has shown that the bobbin probe may not be effective at locations where significant masking signals are present. In addition, the bobbin probe generally cannot detect circumferential cracks, which has been documented in previous NRC communications (e.g., Information Notices 90-49, 94-88, and Generic Letter 95-03). Circumferential cracks can occur at locations of high axial stress (e.g., small-radius U-bends and the tubesheet expansion region).

Plant TS for virtually all PWRs require inspection of the entire length of the hot leg tube within the tubesheet. With some exceptions where specified by the plant TS, the acceptance limits (plugging limits) for these inspections apply to all imperfections along the full length of the tube in the tubesheet on the hot leg side, including axial and circumferential cracks. To the staff's knowledge, however, the bobbin probe has not been demonstrated to be capable of reliably detecting axial or circumferential flaws in the expanded region of tubing inside the tubesheet. Specialized probes are available which have been demonstrated to be capable of detecting such flaws for this application.

Given the limitations of the bobbin probe, industry practice is to supplement the bobbin probe inspection with inspections by specialized probes, such as the rotating pancake coil or +Point™ probe. However, inspecting tubes with these specialized probes is slower than with the bobbin probe. Therefore, these slow-speed probes are typically not applied over the entire length of a tube that is subject to inspection, but only at tube locations where degradation which cannot be reliably detected with the bobbin probe (e.g., circumferential cracks, axial cracks in low-row U-bends and expansion transitions) is known to be present or considered to have a potential to occur. The practice of selecting the type of probe to be used at specific locations along the length of tube involves engineering analysis (termed "degradation assessment" in industry guidelines), which may include an element of judgment, to determine the potential for degradation to occur at various locations.

In 2002, the staff learned that several licensees were not fully implementing inspection methods capable of detecting circumferentially oriented cracks at all locations where the potential for such cracks exists and where, based on available evidence, there is reason to believe such cracks may be present. These licensees were conducting full-length bobbin probe inspections of the tubes and were performing additional inspections using specialized probes to inspect for axial and circumferential cracks at certain locations, including the tube expansion transitions near the top of the tubesheet. The licensees conducted the specialized probe inspections at the tube expansion transitions in an area that extended from 2 inches above the top of the tubesheet to about 5 inches below the top of the tubesheet. At several facilities, circumferential cracks were identified at tube expansion transitions, as well as below the transitions near the bottom of the zone being inspected. These results indicate a potential for circumferential cracks to exist in the tubing below the zone inspected with the specialized probe. However, each licensee also performed an analysis indicating that circumferential cracks below the zone being inspected with the specialized probe would not be detrimental to tube structural and leakage integrity. These licensees concluded, therefore, that additional inspections for circumferential cracks with the specialized probe were unnecessary. These analyses had not been provided to the NRC staff.

The staff became aware of these activities during SG inspections conducted during refueling outages and asked these licensees to submit TS amendment requests or safety analyses to obtain NRC approval of their inspection approaches. The staff reviewed the resulting submittals on a one-cycle basis before the plants restarted. Subsequent to these plant-specific actions, the staff evaluated the appropriate method to interact with licensees on this issue. Given new inspection information indicating that circumferential cracks were occurring in tubes below the expansion transition region, and the potentially generic nature of the issue, the staff decided to communicate the issue to licensees through this generic letter.

Discussion

As part of the inspection process, licensees perform an engineering (degradation) assessment to determine the potential for degradation at specific locations of the tube. The staff recognizes that the potential for degradation may vary from plant to plant based on tube material, operating hours, and other plant-specific factors. However, once licensees have determined what degradation may be present at various locations along the length of the tube, it is the staff position that they should use probes capable of detecting these forms of degradation. Not to do so raises questions about whether the tube inspection practices ensure compliance with the TS in conjunction with 10 CFR Part 50, Appendix B. This staff position is consistent with the position expressed in Section 2.a of Regulatory Guide 1.83, Revision 1, issued in 1975.

In the aforementioned cases, tube inspections with a specialized probe near the top of the tubesheet clearly indicated the potential for circumferential cracks to occur deeper into the tubesheet, beyond the region inspected with the specialized probes. In each case the licensee was aware of the potential for such cracks to exist deeper into the tubesheet, but the licensee did not employ techniques capable of reliably detecting such cracks because the licensee's analysis concluded that such cracks did not have safety implications.

In addition, the staff notes that not inspecting with techniques that are capable of detecting flaws of any type that may be present would allow any such flaws to remain in place. However, most plant TS state that only tubes with imperfections less than 40 percent of the nominal tube wall thickness are acceptable for continued service (there are exceptions specified in some plant TS). Therefore, if licensees do not use probes capable of detecting flaws that may potentially be present, licensees would be allowing flaws to remain inservice which may exceed the applicable TS acceptance criteria (i.e., tube repair or plugging limit). The staff notes that the acceptance or plugging limit for SG tube inspections is a specific TS limit that can only be changed through the license amendment process. Furthermore, even when a probe is capable of finding flaws potentially present, flaws may be inadvertently missed for a variety of reasons (e.g., the flaw size is below the threshold of detection). However, missing a flaw is different than using a probe which is not capable of detecting the forms of degradation that may be present. In other words, the objective of the inspection is to detect flaws of any type that may have the potential to be present along the length of the tube required to be inspected and that may meet or exceed the applicable tube repair criteria.

The staff acknowledges that there may be circumstances in which certain flaws at certain locations may not impair tube integrity even if the TS plugging limit is exceeded. In such circumstances, the staff has reviewed and approved TS amendment requests for alternative tube repair criteria (ARCs) applicable to specified flaw types and/or locations. Some of these ARCs have included special inspection requirements defining the method of inspection to be used when implementing the ARCs. It is the staff's position that if there are locations where certain flaw types can be allowed to exceed existing TS plugging limits, the TS need to be amended to allow the practice. In general, the amendment could include provisions for an ARC and sometimes accompanying special inspection requirements, consistent with past licensing practice. Alternatively, in the case of the aforementioned tubesheet inspection issue, such an amendment could simply clarify the extent of the tube to be inspected within the thickness of the tubesheet, if there is a supporting technical basis that flaws at locations not to be inspected will not impair tube integrity irrespective of the size of the flaws. Pending the submission of such amendment requests, it is the staff's position that licensees are required under existing requirements (TS in conjunction with 10 CFR Part 50, Appendix B) to employ inspection techniques capable of detecting all flaw types which may be present at locations which are required to be inspected pursuant to the TS.

Although this specific example involves inspections in the tubesheet region at plants where cracking had the potential to occur, similar situations could exist at other tube locations for certain degradation mechanisms. As a result, the staff's position applies to all tube locations. In addition, it applies to all PWRs since tube degradation can occur in any steam generator and similar situations could exist at any plant.

Also, for the instances cited above, the safety basis developed by the licensees for not expanding the scope of the specialized probe inspection beyond a specific distance (x-inches) into the tubesheet was that any cracks below that distance were not detrimental to tube integrity. This was based on analyses indicating that tubes only needed a minimum embedment of x-inches into the tubesheet to exhibit acceptable structural and accident leakage integrity. The staff notes that this is a different acceptance standard than the TS acceptance standards (i.e., plugging limits or tube repair criteria) that have been reviewed and approved by

the NRC staff. If the licensee is utilizing a less restrictive acceptance standard compared to the standards in the technical specifications, a license amendment will be needed in order to implement such a standard.

Furthermore, these analyses have been performed to demonstrate that cracks below this embedment distance do not impair SG tube integrity, even if these cracks cause complete severance of the tube. According to many plant final safety analysis reports (FSARs), the SGs were designed in accordance with Section III of the American Society of Mechanical Engineers (ASME) Code. In accordance with Section III of the Code, the original design basis pressure boundary for the tube-to-tubesheet joint included the tube and tubesheet extending down to and including the tube-to-tubesheet weld. The criteria of Section III of the ASME Code constitute the "method of evaluation" for the design basis. These criteria provide a sufficient basis for evaluating the structural and leakage integrity of the original design basis joint. However, the criteria of Section III do not provide a sufficient basis by themselves for evaluating the structural and leakage integrity of a mechanical expansion joint consisting of a tube expanded against the tubesheet over some minimum embedment distance. If a licensee is redefining the design basis pressure boundary and is using a different method of evaluation to demonstrate the structural and leakage integrity of the revised pressure boundary, an analysis under 10 CFR 50.59 would determine whether a license amendment is required.

In summary, for the cases discussed above, the TS required a tube inspection for the full length of the tube within the tubesheet (scope), and the findings from this inspection were required to be evaluated against a repair (plugging) criterion. Neither the scope nor the repair criteria in the TS contained provisions for limiting the inspections through a licensee-approved process.

For the cases cited above, the NRC cannot conclude that the licensees are in compliance with their TS in conjunction with Criteria IX, XI, and XVI of 10 CFR Part 50, Appendix B, with regard to the inspections they are performing. This concern stems, in part, from experience. Some licensees have relied on licensee-controlled analyses to justify not inspecting for degradation in areas where it had the potential to exist. By not inspecting such areas, the licensees have allowed flaws that may have been detected and that may exceed the repair or plugging limit to remain in service. These inspection practices are contrary to the requirements in the TS in conjunction with Criteria IX, XI, and XVI of 10 CFR Part 50, Appendix B, which require the identification of conditions adverse to quality by using qualified techniques and adequate test instrumentation and do not provide for limiting SG tube inspections in the manner described above. In addition, this practice appears contrary to the consistent past practice of amending the TS in cases where existing TS plugging limits are determined to be overly conservative for certain flaw types at certain locations. It is the staff's position that pending a license amendment clarifying the inspection approach to be followed, licensees are required to employ inspection methods capable of detecting all flaw types that may be present at locations that are required to be inspected by the TS, and where flaws at those locations may exceed the applicable TS tube repair criteria.

Based on these staff concerns, the NRC is issuing this generic letter, consistent with the requirements in 10 CFR 50.54(f), to obtain information necessary for the staff to determine if addressees are in compliance with the TS in conjunction with 10 CFR Part 50, Appendix B. In

addition, licensees who have not been implementing inspections consistent with the staff's position should submit a safety assessment that demonstrates their ability to ensure continued safe operation and addresses any differences between their practices and those called for by the staff's position. Safety assessments should be submitted to the NRC for all areas of the tube required to be inspected by the TS, where flaws have the potential to exist and inspection techniques capable of detecting these flaws are not being used.

Requested Information

Within 60 days of the date of this generic letter, addressees are requested to provide the following information to the NRC:

1. Addressees should provide a description of the SG tube inspections performed at their plant during the last inspection. In addition, if they are not using SG tube inspection methods whose capabilities are consistent with the NRC's position, addressees should provide an assessment of how the tube inspections performed at their plant meet the inspection requirements of the TS in conjunction with Criteria IX and XI of 10 CFR Part 50, Appendix B, and corrective action taken in accordance with Appendix B, Criterion XVI. This assessment should also address whether the tube inspection practices are capable of detecting flaws of any type that may potentially be present along the length of the tube required to be inspected and that may exceed the applicable tube repair criteria.

2. If addressees conclude that full compliance with the TS in conjunction with Criteria IX, XI and XVI of 10 CFR Part 50, Appendix B, requires corrective actions, they should discuss their proposed corrective actions (e.g., changing inspection practices consistent with the NRC's position or submitting a TS amendment request with the associated safety basis for limiting the inspections) to achieve full compliance. If addressees choose to change their TS, the staff has included in the Attachment suggested changes to the TS definitions for a tube inspection and for plugging limits to show what may be acceptable to the staff in cases where the tubes are expanded for the full depth of the tubesheet and where the extent of the inspection in the tubesheet region is limited.

3. For plants where SG tube inspections have not been or are not being performed consistent with the NRC's position on the requirements in the TS in conjunction with Criteria IX, XI, and XVI of 10 CFR Part 50, Appendix B, the licensee should submit a safety assessment (i.e., a justification for continued operation based on maintaining tube structural and leakage integrity) that addresses any differences between the licensee's inspection practices and those called for by the NRC's position. Safety assessments should be submitted for all areas of the tube required to be inspected by the TS, where flaws have the potential to exist and inspection techniques capable of detecting these flaws are not being used, and should include the basis for not employing such inspection techniques. The assessment should include an evaluation of (1) whether the inspection practices rely on an acceptance standard (e.g., cracks located at least a minimum distance of x below the top of the tube sheet, even if these cracks cause complete severance of the tube) which is different from the TS acceptance standards (i.e., the tube plugging limits or repair criteria), and (2) whether the safety

assessment constitutes a change to the "method of evaluation" (as defined in 10 CFR 50.59) for establishing the structural and leakage integrity of the joint. If the safety assessment constitutes a change to the method of evaluation under 10 CFR 50.59, the licensee should determine whether a license amendment is necessary pursuant to that regulation.

Required Response

In accordance with 10 CFR 50.54(f), addressees are required to submit written responses to this generic letter. There are two options:

(a) Addressees may choose to submit written responses providing the information requested above within the requested time period. (Addressees who are implementing SG tube inspections in accordance with the staff position set forth in this GL need only describe the last inspections of their SG tubes to allow the staff to verify this.)

(b) Addressees who cannot meet the requested completion date or who choose an alternate course of action are required to notify the NRC of these circumstances in writing as soon as possible but no later than 30 days from the date of this generic letter. The response must address any alternative course of action proposed, including the basis for the acceptability of the proposed alternative course of action and the basis for finding that the SGs remain operable. If the information requested in the previous section of this GL will be subsequently provided, the response must set forth the schedule for submitting the information.

The required written response should be addressed to the U.S. Nuclear Regulatory Commission, ATTN: Document Control Desk, 11555 Rockville Pike, Rockville, Maryland 20852, under oath or affirmation under the provisions of Section 182a of the Atomic Energy Act of 1954, as amended, and 10 CFR 50.54(f). In addition, a copy of the response should be sent to the appropriate regional administrator.

Reasons for Requested Information

This generic letter requests addressees to submit information. The requested information will enable the NRC staff to determine whether licensees are implementing SG tube inspections in accordance with applicable requirements. In cases where licensees are not implementing inspections in such a manner, the requested information will allow the staff to determine whether the licensee's program complies with existing requirements (the plant TS in conjunction with 10 CFR Part 50, Appendix B, and the GDC or the plant-specific design basis, as appropriate).

Backfit Discussion

Under the provisions of Section 182a of the Atomic Energy Act of 1954, as amended, and 10 CFR 50.54(f), this generic letter transmits an information request for the purpose of verifying compliance with applicable existing requirements. Specifically, the requested information will enable the NRC staff to determine whether applicable requirements (plant TS in conjunction

with 10 CFR Part 50, Appendix B) are being met. No backfit is either intended or approved in the context of issuance of this generic letter. Therefore, the staff has not performed a backfit analysis.

Federal Register Notification

A notice of opportunity for public comment on this generic letter was published in the *Federal Register* on May 14, 2003 (68 FR 25909). A total of 15 comments were received, 13 from the nuclear industry and two from the public. The staff considered all comments that were received. The staff's evaluation of the comments is publicly available through the NRC's Agencywide Documents Access and Management System (ADAMS) under Accession No. ML041690373.

Paperwork Reduction Act Statement

This generic letter contains information collection requirements that are subject to the Paperwork Reduction Act of 1995 (44 U.S.C. 3501 et seq.). These information collections were approved by the Office of Management and Budget, approval number 3150-0011, which expires on February 28, 2007.

The burden to the public for these mandatory information collections is estimated to average 60 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the information collection. Send comments regarding this burden estimate or any other aspect of these information collections, including suggestions for reducing the burden, to the Records and FOIA/Privacy Services Branch (T-5 F52), U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, or by Internet electronic mail to INFOCOLLECTS@NRC.GOV;

and to the Desk Officer, Office of Information and Regulatory Affairs, NEOB-10202, (3150-0011), Office of Management and Budget, Washington, DC 20503.

Public Protection Notification

The NRC may not conduct or sponsor, and a person is not required to respond to, a request for information or an information collection requirement unless the requesting document displays a currently valid OMB control number.

If you have any questions about this matter, please contact one of the persons listed below or the appropriate Office of Nuclear Reactor Regulation (NRR) project manager.

Bruce A. Boger, Director
Division of Inspection Program Management
Office of Nuclear Reactor Regulation

Attachment: As stated

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Sample Changes to the TS for Plants Limiting Inspections in the Tubesheet Region

Plugging Limit means the imperfection depth at or beyond which the tube shall be removed from service and is equal to 40% of the nominal tube wall thickness. All tubes with degradation in the portion of the tube from x-inches below the bottom of the expansion transition (or the top of the tubesheet, whichever is lower) to the bottom of the expansion transition (or the top of the tubesheet, whichever is lower), shall be removed from service.

Tube Inspection means an inspection of the steam generator tube from x-inches below the hot-leg expansion transition or the top of tubesheet, whichever is lower, completely around the U-bend to the top support of the cold leg.

Attachment