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#### 4.19 OTSG TUBE INSERVICE INSPECTION

##### Applicability

This Technical Specification applies to the inservice inspection of the OTSG tube portion of the reactor coolant pressure boundary.

##### Objective

The objective of this inservice inspection program is to provide assurance of continued integrity of the tube portion of the Once Through Steam Generators, while at the same time minimizing radiation exposure to personnel in the performance of the inspection.

##### Specification

Each steam generator shall be demonstrated OPERABLE by performance of the following inservice inspection program and the requirements of Specification 3.1.6.3.

##### 4.19.1 Steam Generator Sample Selection and Inspection Methods

- a. Both steam generators shall be determined OPERABLE during shutdown by selecting and inspecting the steam generators at the frequency specified in 4.19.3.
- b. Inservice inspection of steam generator tubing shall include nondestructive examination by eddy-current testing or other equivalent techniques. The inspection equipment shall be calibrated to provide a sensitivity that will detect defects with a penetration of 20 percent or more of the minimum allowable as-manufactured tube wall thickness.

##### 4.19.2 Steam Generator Tube Sample Selection and Inspection

The inservice inspection of steam generator tubes shall be performed at the frequencies specified in Specification 4.19.3 and the inspected tubes shall be verified acceptable per the acceptance criteria of Specification 4.19.4. The tubes selected for each inservice inspection shall include a nominal 20% of the total number of inservice tubes in each steam generator such that 100% inspection of the inservice tubes in each steam generator, over five inspection (refueling) intervals, is achieved.

The tubes selected for each inservice inspection shall include a representative sample of tubes to include areas identified by relevant industry (OTSG) experience as likely to produce higher degraded or defective tube population densities. Tube inspections will be conducted in accordance with Section 4.19.4.a.8. If any selected tube does not permit the passage of the eddy current probe for a tube inspection, this shall be recorded and an adjacent (or representative) tube shall be selected and subjected to a tube inspection.

Tubes in the following special groups may be excluded from the initial 20% sample if all tubes in a group in both steam generators are inspected. No credit will be taken for these tubes in meeting minimum sample size requirements.

- (1) Group A-1: Tubes in rows 73 through 79 adjacent to the open inspection lane, and tubes between and on lines drawn from tube 66-1 to tube 75-15 and from 86-1 to 77-15.
- (2) Group A-2: Tubes having a drilled opening in the 15th support plate.

4.19.2.1 The following additional tubes shall be inspected during each refueling interval inspection:

1. All non-plugged tubes that previously had detectable wall penetrations (>20% T.W.).
2. Tubes having wear indications at or near the tube support plates.

4.19.2.2 Based on the results of the inspection, the sample size will be expanded as follows:

1. If active degradation has been found in a generator, all inservice tubes or portions of tubes within an inspection boundary encompassing the region of active degradation shall be inspected. The inspection boundary definition is based on engineering judgement, but is at least two tubes free of active degradation or defects in all applicable directions from tubes containing active degradation. Active degradation is defined as detectable imperfections exceeding 20% through-wall, except for detectable imperfections which have increased by less than 10% thru-wall since the previous inspection.
2. If the initial inspection results are category C-3, the inspection shall be expanded to include 100% of the inservice tubes in the affected steam generator, unless the observed degradation is confined in a specific region or tube population of the steam generator, and a 100% inspection has been conducted in that region or tube population. Defective tubes or tubes with active degradation outside that region or tube population will be bounded by the criteria specified in 4.19.2.2.1.
3. Where special inspections are performed pursuant to 4.19.2, Group A-1 and A-2, defective or degraded tubes found as a result of the inspection shall be included in determining the Inspection Results Category for that special inspection but need not be included in determining the Inspection Results Category for the general steam generator inspection.
4. Partial tube length inspection of the area of interest may be permitted where experience supports the isolated location of degradation.

#### 4.19.3 Inspection Frequencies

The required inservice inspections of steam generator tubes shall be performed at the following frequencies:

- a. Inservice inspections should be performed every refueling interval, not more than 24 calendar months after the previous inspection.

b. Additional, unscheduled inservice inspections of sample size sufficient to determine the extent of DTSG tube damage shall be performed on affected steam generators(s) during the shutdown subsequent to any of the following conditions. The initial inspection sample size and expansion criteria is also indicated:

1. Primary-to-secondary tube leaks (not including leaks originating from tube-to-tube sheet welds or previously plugged tubes) in excess of the limits of Specification 3.1.6.3. Bounding will be in accordance with Specification 4.19.2.2.1. TS 4.19.2.2 expansion criteria is not applicable to this condition.
2. A seismic occurrence greater than the Operating Basis Earthquake. The initial sample size shall be 3%, including previously degraded tubes. Expansion of initial sample size will be based on TS 4.19.2.2 for this condition.
3. A large break loss of coolant accident requiring actuation of the core flooding systems. The initial sample size shall be 20%, including previously degraded tubes. Expansion of initial sample size will be based on TS 4.19.2.2 for this condition.
4. A major main steam line or feedwater line break. The initial sample size shall be 20%, including previously degraded tubes. Expansion of initial sample size will be based on TS 4.19.2.2 for this condition.

#### 4.19.4 Acceptance Criteria

a. As used in the Specification:

1. Imperfection means an exception to the dimensions, finish or contour of a tube from that required by fabrication drawing or specifications. Eddy current testing indications below 20% of the nominal tube wall thickness, if detectable, may be considered as imperfections.
2. Degradation means a service-induced cracking, wastage, wear or general corrosion occurring on either inside or outside of a tube.
3. Degraded Tube means a tube containing imperfections  $\geq 20\%$  of the nominal wall thickness caused by degradation.
4. % Degradation means the percentage of the tube wall thickness affected or removed by degradation.
5. Defect means an imperfection of such severity that it exceeds the repair limit. A tube containing a defect is defective.



6. Repair Limit means the extent of degradation at or beyond which the tube shall be repaired or removed from service because it may become unserviceable prior to the next inspection.

This limit is equal to 40% of the nominal tube wall thickness.

7. Unserviceable describes the condition of a tube if it leaks or contains a defect large enough to affect its structural integrity in the event of an Operating Basis Earthquake, a loss of coolant accident requiring actuation of the Engineered Safeguards, or main steam line or feedwater line break.

8. Tube Inspection means an inspection of the steam generator tube from the bottom of the upper tube sheet completely to the top of the lower tubesheet, except during expansion as permitted by 4.19.2.2.4, above.

9. Category C-3 is defined as more than 10% of the total tubes inspected in a steam generator are degraded tubes or more than 1% of the inspected tubes are defective. In all inspections, previously degraded tubes must exhibit significant (>10%) further wall penetrations to be included in the above percentage calculations.

- b. The steam generator shall be determined OPERABLE after completing the corresponding actions (removal from service by plugging, or repair by kinetic expansion, sleeving, or other methods, of all tubes exceeding the repair limit and all tubes containing through wall cracks) required to repair defective tubes or remove them from service.

#### 4.19.5 Reports

- a. Following the completion of each inservice inspection of steam generator tubes, the number of tubes repaired or removed from service in each steam generator shall be reported to the NRC within 15 days.
- b. The complete results of the steam generator tube inservice inspection shall be reported to the NRC within 12 months following completion of the inspection. This report shall include:
1. Number and extent of tubes inspected.
  2. Location and percent of wall-thickness penetration for each indication of degradation.
  3. Identification of tubes repaired or removed from service.
  4. Basis for determining that the extent of occurrence of new defective tubes has been satisfactorily bounded by additional sample inspection performed.

- c. Results of steam generator tube inspections which fall into Category C-3 require notification in accordance with 10 CFR 50.72 prior to resumption of plant operation. The written follow-up of this report shall provide a description of investigations conducted to determine the cause of the tube degradation and corrective measures taken to prevent recurrence in accordance with 10 CFR 50.73.

#### Bases

The Surveillance Requirements for inspections of the steam generator tubes ensure that the structural integrity of this portion of the RCS will be maintained.

The program for inservice inspection of steam generator tubes is based on a modification of Electric Power Research Institute (EPRI) "PWR Steam Generator Inspection Guidelines, Rev. 2." Inservice inspection of steam generator tubing is essential in order to maintain surveillance of the conditions of the tubes in the event that there is evidence of mechanical damage or progressive degradation due to design, manufacturing errors, or inservice conditions. Inservice inspection of steam generator tubing also provides a means of characterizing the nature and cause of any tube degradation so that corrective measures can be taken. All non-plugged steam generator tubes will be inspected over 5 consecutive inspection intervals.

The Unit is expected to be operated in a manner such that the primary and secondary coolant will be maintained within those chemistry limits found to result in negligible corrosion of the steam generator tubes. If the primary or secondary coolant chemistry is not maintained within these chemistry limits, localized corrosion may result.

The extent of tube degradation during plant operation would be limited by the limitation of total steam generator tube leakage between the primary coolant system and the secondary coolant system (primary-to-secondary leakage = 1 gpm). In-service tube leakage in excess of this limit will require an unscheduled inspection following plant shutdown during which the leaking tubes will be located and repaired or removed from service.

Wastage-type defects are unlikely with proper chemistry treatment of the primary or secondary coolant. However, even if a defect would develop in service, it will be found during scheduled inservice steam generator tube examinations. Steam generator tube inspections of operating plants have demonstrated the capability to reliably detect degradation that has penetrated 20% of the original tube wall thickness.

Where damage mechanisms are determined to be relevant to TMI-1 based on experience in similar steam generators (OTSGs) in other plants, a representative sample of tubes in those suspect areas will be included in the inservice inspection sample. When active degradation is found, additional inspection(s) will occur to bound the problem by at least two unplugged tubes free of active degradation or defects in all applicable directions. If it is a systematic occurrence, then sufficient tubes will be inspected to bound the problem. The tubes examined in the additional sample expansion should be examined tubesheet to tubesheet unless there is testing or experience to justify otherwise.

Plugging or repair by kinetic expansion, sleeving, or other method will be required for degradation equal to or in excess of 40% of the tube nominal wall thickness.



RESPONSE TO NRC COMMENTS RELATED TO TSCR NO. 193

1. Proposed Specification 4.19.2, first paragraph

For purposes of clarification, the following sentences should be added to the end of this paragraph: "A tube inspection (pursuant to Specification 4.19.4.a.8) should be performed on each selected tube."

Response

Proposed specification 4.19.2, second paragraph, has been revised to reflect that tube inspections will be conducted in accordance with specification 4.19.4.a.8.

2. Proposed Specification 4.19.2.1.1

The second sentence of this proposed specification is unacceptable to the staff and should be deleted. The staff rules that unplugged tubes that previously had detectable wall penetrations (>20%) have reduced structural margins ability to burst, although these margins are still within acceptable limits (assuming these tubes were found previously to satisfy the repair limit in Specification 4.19.4.a.6). Given the reduced structural margins, any further damage progression in the future must be detected quickly to preclude the potential for rupture. For this reason the staff continues to believe that tubes with previous indications should be inspected at each steam generator inspection. The staff also notes that its position on this matter is consistent with the recommendation in the EPRI guidelines.

Response

The second sentence in proposed specification 4.19.2.1.1 has been deleted in its entirety. GPU Nuclear will continue to inspect tubes with previous indications during future refueling interval OTSG Eddy Current examinations, regardless of whether or not the indications exhibit active degradation. Previously degraded tubes are also inspected when required by TS 4.19.3.b for unscheduled inspections.

3. Proposed Specification 4.19.2.2

For purposes of clarification, the word "expanded" should be used in lieu of the words "expanded/modified" in the proposed specification.

Response

The word "expanded" has replaced the term "expanded/modified" in proposed specification 4.19.2.2.

4. Proposed Specification 4.19.2.2.1

- a. The words "active degradation" need to be defined. We suggest that "active degradation" be defined on detectable imperfections exceeding 20% through-wall, except for detectable imperfections which have increased by less than 10% since the previous inspection.

Response

Proposed specification 4.19.2.2.1 has been revised to incorporate the above definition for "active degradation."

- b. The expression "with the exception of 4.19.2.1.1 above" should be deleted because it is no longer needed in view of Comment 4a above. The staff also notes that the expression is inappropriate because it deals with indications found during previous inspections.

Response

The expression "with the exception of 4.19.2.1.1 above" has been deleted from proposed specification 4.19.2.2.1.

- c. The expression "additional tubes or portions of tubes, necessary to bound the problem, will be inspected" is vague. The staff believes that this expression should be clarified by stating that all tubes or portions of tubes within an inspection boundary encompassing the region of active degradation should be inspected. The inspection boundary should be defined so as to bound all tubes with "active degradation" (as defined above) by an amount based on the licensee's judgement, but by at least two tubes in all applicable directions.

Response

Proposed specification 4.19.2.2.1 has been revised to state that "all in-service tubes or portions of tubes within an inspection boundary encompassing the region of active degradation shall be inspected."

Additionally, the revised specification identifies the bounding criteria when active degradation is found. Hence, it addresses the NRC's request that all tubes with active degradation be bounded. This specification has also been expanded to reflect that bounding will be based on at least two (2) tubes in all applicable directions from tubes containing active degradation, unless all in-service tubes or portions of tubes constituting the region or population of active degradation have been inspected.

- d. Consistent with comment 5.c below, the staff believes that in the case where the results of the initial inspection sample are Category C-3 (as currently defined in the Technical Specifications), a minimum 20% random sample of tubes located outside the inspection boundary shall be inspected with no degraded or defective tubes found. (Note that under proposed specification 4.19.2, the initial 20% sample is not necessarily random throughout the steam generator).

Response

TSCR No. 193 (Specification 4.19.4.a.9) has been revised to incorporate and define inspection result category C-3, as defined in the current technical specifications. Our response to NRC comment 5.c below provides a discussion on expanding the initial 20% inspection sample when the results of the inspection is category C-3.

5. Proposed Specification 4.19.2.2.2

- a. The expression "tube containing a defect" in the proposed specification refers to a tube with an imperfection which exceeds the repair limit (see definition of "defect" in specification 4.19.4.a.5). Consistent with the current sample expansion philosophy of the Technical Specification, we believe the above expression should be replaced by the words "degraded tube" (i.e., tube containing imperfections >20% of the normal wall thickness as defined in specification 4.19.4.a.3), and the word "defect-free" should be replaced by the word "non-degraded."

Response

Specification 4.19.2.2.2 has been revised in its entirety. The revision provides for expanding the inspection to 100% of the affected steam generator under certain conditions when the initial inspection result is C-3.

Additionally, the use of the terms "defect-free" and "tube containing a defect" have been deleted. In bounding a tube with a defect or active degradation, where none existed before, the tubes comprising the expansion must be free of defects or active degradation.

For tubes with known degradation found during previous inspections no expansion is required, unless the degradation has become active.

- b. The circumstances in which a degraded tube would be considered to be an isolated occurrence is not clear and, therefore, needs to be clarified. This clarification should also address the issue of how many degraded tubes could be considered to be isolated occurrences.

Response

Specification 4.19.2.2.2 has been revised in its entirety. The use of the term "isolated occurrence" has been deleted. As discussed in our responses to NRC comments 5a and 5c, a consistent bounding methodology with provisions for further expansion has been incorporated.

- c. Specification 4.19.2.2.2 should be modified to state that it is not applicable in cases where the results of the initial inspection sample are Category C-3 (as presently defined in the Technical Specifications). The current Technical Specifications require that in cases where the results of the initial inspection sample are Category C-3, the inspections shall be expanded to include 100% of the tubes in the affected steam generator. The staff believes that inspection of fewer than 100% of the tubes, under these circumstances, is justified only in cases where (1) the observed degradation mechanism is confined to a specific region of the steam generator, (2) a 100% inspection has been conducted in that region, (3) the regions of the tube bundle outside the region receiving the 100% inspections have been subjected to a 20% random sample, and (4) no degraded tubes are found outside the region receiving the 100% inspection.

Response

Specification 4.19.2.2.2 has been revised in its entirety. The specification section now includes a C-3 inspection results category. If the initial inspection results are category C-3 and are not confined to a specific region, the inspection will be expanded to 100% of the remaining in-service tubes in the affected steam generator. NRC comment 5c also identifies four (4) circumstances under which the staff believes 100% inspection of the affected steam generator is not required, when the initial inspection results are category C-3. GPUN agrees with circumstances 1 and 2, which state that the observed degradation mechanism is confined to a specific region of the steam generator and a 100% inspection has been conducted in that region. GPUN disagrees with circumstances 3 and 4, which require that tubes outside the specific region receiving the 100% inspection be subject to a 20% random sample selection and that no degraded tubes are found outside this specific region. The following discussion addresses our disagreements with NRC comments 5.c.3 and 5.c.4.

The initial 20% sample size is selected to be representative of the entire steam generator. Thus the regions of the tube bundle outside the region receiving the 100% inspection are subjected to a 20% examination during the initial sample. This provides adequate assurance that tubes outside a confined region, with indications similar to defective tubes or tubes with active degradation within the confined region, would be found. Unplugged tubes that previously had detectable degradation (>20%) or tubes with active degradation, which is not similar to the degradation which necessitated the 100% inspection of the confined region, may exist outside that region.



Under these conditions it is not necessary to perform a 20% random sample of the in-service tubes outside the confined region. This is due to the fact that defective tubes or tubes with active degradation outside the confined region, with indications different from those in the confined region, would still be subject to the expansion criteria in specification 4.19.2.2.1. This serves to increase the initial sample size and provides additional assurance that the affected regions have been defined and inspected.

6. Proposed Specification 4.19.3.b

The proposal to inspect a sample sufficient to determine the extent of DTSG tube degradation needs to be clarified to include a specific sampling strategy.

Response

Specification 4.19.3.b has been revised to include initial sample sizes for steam generator inspections necessitated by the four (4) conditions identified in the specification. The initial sample sizes vary and are directly related to the respective effect on steam generator tube loading during these accident conditions.

7. Proposed Specification 4.19.5

The licensee is proposing to delete Specification 4.19.5.c which calls for prompt notification of the NRC staff in accordance with 10 CFR 50.72 when steam generator inspection results are in Category C-3 (as defined in the current Technical Specifications). The staff believes that Specification 4.19.5.c should be retained. Category C-3 results represent a significant level of degradation activity, and the staff needs to be kept fully informed on such developments on a timely basis.

Response

The TSCR has been revised to require NRC notification in accordance with 10 CFR 50.72 when the steam generator inspection results are Category C-3, as defined in the TSCR.