SGTF/NRC Public Meeting

January 26, 2021

Agenda for Public Meeting

- Introductions
- Opening Remarks
- Discussions
  - Technical Specification Reporting Requirements Template
    - NRC comments to Industry’s Draft
  - Industry’s Plans for Loose Parts Strategy
  - Enhanced Probe Inspections
  - High Stress Tube Reanalysis Status

Opening Remarks

- NRC
- Industry

Technical Specification Reporting Template Industry's Draft
Helen Cothron, EPRI

Design and Operating Parameters – Not in Section 5.6.7

- Steam generator design overview
- Model
- Tube material
- No. of SGs per Unit
- Number of tubes
- Nominal tube diameter and wall thickness
- Style of support plate and material
- Outage the prior SG inspections were completed
- Effective full power months of operation since the prior SG inspection
- Cumulative effective full power years at the current inspection
- Date of entry into Mode 4 from current inspection outage
- SG primary-to-secondary leak rate above minimum detectable levels observed since the last inspection and how it trended with time
- Nominal hot-leg temperature(s) (T_{HOT}) during the prior inspection period
- Tube sub-populations with increased degradation susceptibility (e.g., tubes with potential high residual stress ("- two sigma"), other areas based on growth rates or design features)
- A list of any deviations taken from Mandatory and/or Needed (Shall) requirements important to tube integrity from the EPRI Guidelines referenced by NEI 97-06 since the last inspection.
- SG schematic w/o dimensions

The information that will not change may reference a past 180-day report

Example of Tabular Response

Steam Generator Design and Operating Parameters	
SG Model / Tube Material / # SGs per unit	Areva EOTSG / Alloy 690TT / 2
# of tubes per SG / Nominal Tube Dia / tube thickness	15,597 / 0.625 in / 0.037 in
Support Plate Style / Material	Broached Trefoil / Stainless Steel
Last Inspection Date	October 2017
EFPM since the last inspection	23
Total cumulative SG EFPY	20
Mode 4 entry	March 10, 2020
Observed P/S Leak Rate since the last inspection and how it trended with time	7 gpd, measured by X and trended over the cycle with no change
Nominal indicated value of Thot during Cycle X at full power	604 degrees F
Degradation mechanism sub population	Describe all sub populations (for example: potential high residual stress tubes or central cavity wear)
Deviations from SGMP guidelines since the last inspection	None
Steam Generator Schematic	Attach a schematic without dimensions

Example of Paragraph Response

- The steam generators are once-through Model EOTSG designed by AREVA. The tube material is Alloy 690 thermally treated, and there are two SGs in this unit. Attached is a steam generator schematic without dimensions. There are 15,597 tubes 0.625 diameter and 0.037 thickness. The support plates are stainless steel 410 broached trefoil. Both SG's were last inspected in October 2017. 100% inspection was performed. The SGs operated 23 EFPM to the current inspection. Mode 4 was entered March 10, 2020. This unit had 7 gpd leakage measured by X and trended over the cycle with no change. The cause of the leakage is unknown. The nominal Thot during Cycle X at full power was 604 degrees F.
- For Alloy 690TT an example of how the SGs are split into sub-populations could be because of different types of wear growth rates: The SGs are split into three zones based on the flaw shapes and growth rate of the degradation observed. There are also drilled hole location within one of those zones. Each zone has unique distributions of growth rates based on past and present inspection data. Also, each zone has different flaw shape parameters. Using the zones better captures most of the deeper indications and higher growth rates into one zone. For Alloy 600TT tubing an example would be potential high residual stress tubes: There are X tubes that are in the -2 sigma population, describe how many are in each SG. Another example is periphery tubes for foreign objects and foreign object wear.
- List any deviations from SGMP guidelines that are important to tube integrity such as deviations from the Examination Guidelines, Integrity Assessment Guidelines, or In Situ Pressure Test Guidelines

Inspections Performed – Required by Tech Spec Section 5.6.7

- The scope of primary side inspections performed on each SG (section 5.6.7.a) and if applicable, a discussion of the reason for scope expansion

<u>Example Response</u>

The scope of the inspection performed on both 2A and 2B steam generators (SG) included 100% of the in-service tubes in each SG. All in-service tubes were inspected with bobbin probe. In addition, an array probe inspection was performed in the 2A steam generator of the periphery tube five (5) tubes deep up to the 1st support plate. Special Interest (array coil) inspections were also performed on selected indications. All plugs were visually inspected. A visual inspection of the inlet and outlet bowl cladding was performed.   Identified cracking at the top of the tubesheet array sample and expanded to 100% in that steam generator and a sample in the other steam generators.

Inspections Performed – Required by Tech Spec Section 5.6.7

- The nondestructive examination techniques used for tubes with increased degradation susceptibility (section 5.6.7.b)

<u>Example Response</u>

Array probe technology was used for all potential high residual stress tubes. Rotating coil technology was used for all hot leg dents/dings. Cold leg dents/dings were not inspected with a rotating coil because this mechanism is not considered a potential mechanism for these steam generators.

- We left this requirement out of our initial draft – The nondestructive examination techniques utilized for all other mechanisms (section 5.6.7.c.1)

<u>Example Response</u>

Full length bobbin coil examination of 100% of the tubing in all four SGs.

Inspections Performed – Required by Tech Spec Section 5.6.7

- The location, orientation (if linear), measured size (if available), and voltage responses of each indication. For tube wear at support structures less than 20 percent through-wall, only the total number of indications needs to be reported (section 5.6.7.c.2).

<u>Example Response</u>

Provide the list of indications from final report greater than or equal to 20%TW, the measured size and voltage responses. Example:

SG	Row	Col	Location/Elevation	Degradation	%TW	Orientation	Length	Voltage	Probe
1	14	40	05H +.25”	Cracking	50%	Axial	.25”	1 volt	+Point
2	16	35	07H +.3”	TSP Wear	55%			2 volts	Bobbin

Provide at statement regarding indications less than 20% such as, there are 8059 indications in 4942 tubes <20% TW in the 2A SG and 7054 indications in 4313 tubes in the 2B SG.

Inspections Performed – Required by Tech Spec Section 5.6.7

- A description of the condition monitoring assessment and results, including the margin to the tube integrity performance criteria and comparison with the margin predicted to exist at the inspection by the previous forward-looking tube integrity assessment (section 5.6.7.c.3). Discuss any degradation that was not bounded by the prior operational assessment in terms of projected maximum flaw dimensions, minimum burst strength, and/or accident induced leak rate. Provide details of any in situ pressure test

Example Response

An Arithmetic methodology was used for condition monitoring. Below is the limiting indication of each degradation mechanism compared to the condition monitoring limit

Degradation Mechanism (wear)	Maximum depth (%)	CM limit depth (%)
Tube support tapered	47	69.4
Tube support flat	33	54.9
Drilled Tube support	27	48.7
Tube to tube	12	52.4
Presumed foreign object	13	51.3

An example of a Monte Carlo assessment below:

We will add a CM Curve with indications from the inspection plotted on the curve.

Example continued

If results are bounded by predictions, provide a table comparing inspection results to the prior OA projections.

This table is an example for deterministic assessments

Degradation Mechanism (wear)	X2R28 Projected Limiting depth (%)	X2R29 Limiting As-Found depth (%)
Tapered support	64.2	47
Tube support flat	48.5	33
Drilled tube support	43.5	27
Tube to tube	36.5	12

An example for probabilistic assessment: Forward looking assessment software will typically project a limiting burst pressure at the end of cycle for each mechanism or a limiting flaw size at the end of the cycle. The comparison then would be either the calculated burst pressure of the limiting flaw or the calculated size of the limiting flaw compared with projections.

Example continued

One indication exceeded structural performance criterion by calculation and was in situ pressure tested. It was an axial crack-like indication at the top of the tubesheet. NDE measured maximum depth was 100% TW, average depth was 60%, and length was 0.5”. The tube was subjected to a localized in situ pressure test. The test pressures were 1369 psig for normal operating pressure, 1460 psig for accident induced leakage pressure, and 4107 psig for 3dP pressure. The Plus Point voltage was measured at 2 volts. There was no leakage at normal or accident induced leakage pressures. The indication leaked at 3dP at 0.01 gpm but did not burst. Therefore, the tube met structural and leakage performance criteria. No post eddy current was performed.

Note: If post eddy current is performed, report the change in volts and maximum depth.

Inspections Performed – Required by Tech Spec Section 5.6.7

- The location of each tube plugged [or repaired] during the inspection outage (section 5.6.7.c.4 requires the number of tubes plugged or repaired), and the reason each tube was plugged.

<u>Example Response</u>

A listing of each tube plugged (SG, Row, and Column) and the reason, such as tube support plate wear greater than 40% TW.

- The repair methods utilized, and the number of tubes repaired by each repair method (section 5.6.7.c.5).

<u>Example Response</u>

This report is only required if sleeving or other repairs are being made. These types of repairs must be approved by the NRC.

Inspections Performed – Required by Tech Spec Section 5.6.7

- An analysis summary of the tube integrity conditions predicted to exist at the next scheduled inspection (the forward-looking tube integrity assessment) relative to the applicable performance criteria, including the analysis methodology, inputs, and results. (section 5.6.7.d). The effective full power months of operation permitted for the current operational assessment.

Example Response

The limiting degradation mechanism is tube support plate wear and after 72 effective full power months, it is predicted that the worst-case wear would be no greater than X%TW and therefore would meet the performance criteria.

For tube support plate wear, a full bundle, fully probabilistic methodology was used to predict the conditions at the next inspection. Provide the information necessary to explain the population of indications left inservice, projected initiations, how growth rates were developed. The average growth rate used was XX and the 95th percentile growth rate was XX.

The predicted margin relative to the applicable end of cycle acceptance criteria for all degradation mechanisms is in the table below

Example continued

Degradation Mechanism (wear)	Maximum depth (%) Predicted at Next Inspection	Structural limit depth (%)
Tube support tapered	47	69.4
Tube support flat	33	54.9
Drilled Tube support	27	48.7
Tube to tube	12	52.4
Presumed foreign object	13	51.3

The forward-looking assessment supports 72 EFPM.

Inspections Performed – Required by Tech Spec Section 5.6.7

- The number and percentage of tubes plugged [or repaired] to date, and the effective plugging percentage (if applicable) in each SG (section 5.6.7.e)

Example Response

Steam Generator	2A	2B	Total
Prior to EOC-29	62	84	146
EOC-29	17	30	47
Total	79	114	193
% Plugged	0.51%	0.73%	0.62%

Inspections Performed – Required by Tech Spec Section 5.6.7

- The scope and results of secondary-side inspections performed in each SG (section 5.6.7.f). The number, type, and location (if available) of loose parts that could damage tubes removed or left in service in each SG
  - The requirement to report scope is not in Tech Specs

Example Response

Foreign object search and retrieval was performed in all SGs. A total of 3 foreign objects were removed. Present a table of foreign objects identified by visual inspections listed by SG, Row, Col, location (TTS or TSP) and indicating whether the objects were removed. Objects left in the bundle have an evaluation documenting safe operation till next inspection.

Describe upper internals inspections performed and results (if performed).

Maintenance/Other Inspections Performed - Not Included in Tech Specs

- The scope, method, and results of secondary-side cleaning performed in each SG

Example Response

Advanced scale conditioning agents were applied during this outage in all SGs followed by sludge lancing. A best estimate of deposits removed is a total of 5,000 pounds. Report results of sludge lancing if no chemical cleaning was performed.

- The results of primary side component visual inspections performed in each SG

Example Response

For recirculating SGs, report on channel head inspections that were performed on plug locations, divider plate and associated welds, tube-to-tubesheet welds, and cladding.

Industry's Plans for Loose Parts Strategy
Lee Friant

NRC’s Feedbck on Loose Parts Management

- Longer primary inspection intervals may increase tubing susceptibility to loose part damage
- Plant operating experience with loose parts varies
  - Design (some have loose part strainers)
  - Primary inspection strategy and technique POD
  - Secondary inspections (FOSAR) frequency
  - Foreign material exclusion program effectiveness
- Basis for inspection approach differences not always clear to NRC staff
- Development of a comprehensive industry strategy based on experience, analysis, and with minimum requirements, seems prudent to NRC staff

Integrity Assessment Guidelines Will Address This Issue

- Current Thoughts:
  - Requirement for a secondary side maintenance plan to manage foreign objects
  - Graded approach based on data (design, experience)
    - Requirements/recommendations for minimum scope for primary and secondary inspections
  - Assessment that could be reviewed while developing secondary side strategy
- This may only be required for steam generators that are operating longer periods (96 EFPM or 72 EFPM)

Important Requirements in Current Integrity Assessment Guidelines

- The SG program shall include measures to maintain the SG secondary-side integrity as required by NEI 97-06
- When no DA is performed (i.e., the outage involves no primary side tube inspections), planned secondary side inspection and cleaning intervals shall be validated per Section 11.2.4
- Secondary side component degradation shall, as a minimum, be documented and evaluated within the licensee's corrective action program.
- The OA shall include aspects of secondary side conditions that could affect tube integrity such as foreign material remaining in the SGs, material degradation that could generate foreign objects during operation, and degradation of support structures.
- The OA shall establish the acceptable inspection interval for degraded secondary side components that could impact tube integrity during future operation
- The SG secondary side integrity assessment shall determine an appropriate foreign object search and retrieval (FOSAR) inspection interval.

Important Requirements in Current Integrity Assessment Guidelines

- All foreign material that has the potential to challenge tube integrity shall be removed from the SGs, given the limitations of the equipment and personnel dose.
- Foreign material removed from the SGs, either by lancing or by FOSAR, shall be documented and evaluated for potential impact to tube integrity, and also considered when planning for future inspections.
- Foreign objects that are irretrievable shall be evaluated or remediated by stabilizing and plugging the affected or potentially affected tubes.
- Irretrievable foreign material that has caused tube wear or is considered to have the potential to cause tube wear shall be inspected on the primary and secondary side during future SG inspections.

Important Requirements in Current Integrity Assessment Guidelines

- If subsequent inspections reveal that the foreign object has shifted position such that the integrity of neighboring inservice tubes could be affected, or if the object is no longer present in the same location, the potential for degradation of the neighboring tubes shall be evaluated.
- Tube integrity shall be evaluated with technique(s) with quantified sizing uncertainties.
- With regard to foreign objects, the scenarios are numerous and specific expansion scope cannot be prescribed for each potential scenario. The inspection scope shall support the proposed inspection interval.
- The frequency of secondary side internals examinations shall be established to ensure that SG safety functions will not be jeopardized by degraded secondary side subcomponents

Enhanced Probe Inspections
Steve Brown, Entergy

NRC’s Feedback on Alloy 600TT Inspection Intervals

- Alloy 600TT:54 EFPM (adds one cycle) for some plants
  - Doesn’t benefit 24-month fuel cycle plants
- Conditional 72 EFPM (adds two cycles) if:
  - (1) plants have no cracking history (excludes H* ARC) and
    - Does this mean ever in history? Could this be and/or?
  - (2) 100% enhanced probe inspections are performed
- If cracks detected, inspect next outage.
  - Conditional relaxation to inspect at 2ndRFO if:
    - (1) 100% enhanced probe inspections are performed

Enhanced Technology

- The best probe for the job depends on what mechanism is expected and the location in the bundle
  - This wording needs to be open and not specific to a certain probe type
- Current wording regarding probe technology
  - The number and portions of the tubes inspected and methods of inspection shall be performed with the objective of detecting flaws of any type (e.g., volumetric flaws, axial and circumferential cracks) that may be present along the length of the tube, from the tube-to-tubesheet weld at the tube inlet to the tube-to-tubesheet weld at the tube outlet, and that may satisfy the applicable tube plugging [or repair] criteria.
- NRC's Proposed change for Alloy 600TT Tubing on 72 EFPM operating interval
  - 100% Enhanced Probe Definition
    - Tube end to tube end (except below H* distance) with probes equivalent to or better than array probe technology
    - For regions where array probe technology is not possible, tube inspection techniques applied shall be capable of detecting all forms of existing and potential degradation in that region

High Stress Tube Rescreening Status
Jay Smith, Westinghouse

Westinghouse Corrective Action Program High Stress Tube Screening Extent of Condition

- Westinghouse had previously communicated to the Staff during the October 28, 2020 Industry-NRC SGTF Meeting a condition where a high stress tube was not identified in the original high stress tube screening analysis for long row tubes performed in 2004 for one plant (Plant D2).
- Westinghouse entered the condition into their Corrective Action Program for apparent cause and extent of condition review.
  - The apparent cause of the issue was a miscommunication between Engineering and the Data Analyst performing the original screening regarding the definition of a results code ("LAR")
  - Extent of condition reviews were required for all plants that Westinghouse had performed the long row high stress tube screening (8 plants)

Westinghouse Corrective Action Program High Stress Tube Screening Extent of Condition

- Extent of condition reviews have been completed (results final) for 2 of 8 plants.
  - Plant D2 (subject of CAP); EOC review identified 14 in service tubes to be added to the plants high stress tube list.
    - All 14 were LAR tubes
  - Plant B; No additional high stress tubes identified

- The extent of condition reviews for 4 of 8 plants have been completed but pending review and verification.
  - No additional high stress tubes were identified

- The extent of condition reviews for the remaining 2 of 8 plants are in-progress.

Next Steps

- Discussion
- We have a list of plant needs so that a prioritization can be developed
  - There may be three plants that need the site-specific approval for fall 2021 outages

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