

Global Engineering Services

Steam Generator Tube Wear Volume

Predictive Model

Background

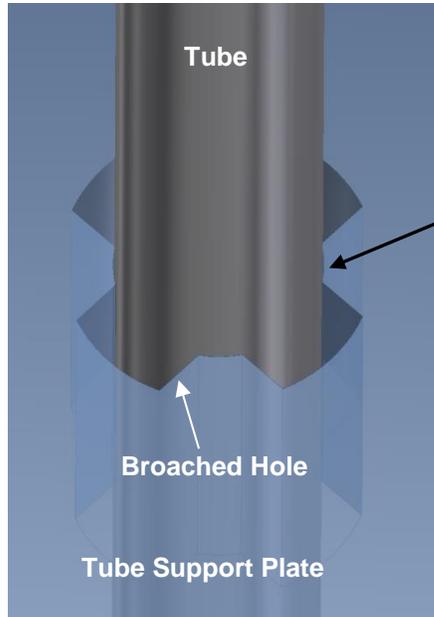
Steam generator (SG) eddy current inspections are often among the most costly contracted services performed during an outage. The non-destructive examination and subsequent plugging of large numbers of SG tubes due to wear indications can be a significant cause of economic stress for operators of pressurized water reactors. Further, the ability to skip future outage SG inspections can be directly influenced and limited by the associated tube wear degradation growth rates. This limitation can even be significant enough that the allowable duration between SG eddy current inspections is less than that permitted by the plant technical specifications. Historically, SG engineering analysis methods have largely relied on depth-based tube wear assessments. However, recent technical advances are changing the SG tube integrity analysis approach.

Description

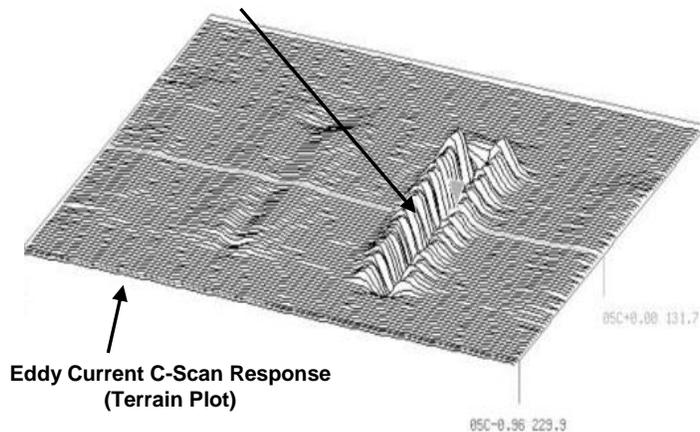
Westinghouse has developed a patented engineering model which uses the innovative concept of tube wear flow volume removal as the predictive parameter. Through retroactive analyses and applications, this method has been shown to lead to improved accuracy of projected tube wear indication depths at future inspections and reduced uncertainty levels associated with the SG tube integrity engineering assessments. As a result, the SG tube wear volume-based models can be used to:

- Reduce the number of tubes required to be plugged during the outage
- Justify extended operating periods between SG eddy current inspections
- Technically support revisions to the Technical Specifications to extend SG tube inspection periods.

Although applicable to nearly all types of SGs, this model is best suited for plants with modest to aggressive SG tube wear degradation.



Tapered Tube Wear at Broached Hole

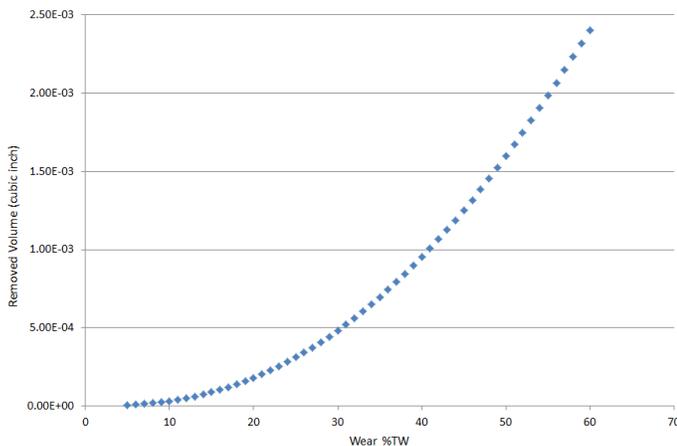


To the left is a typical steam generator tube intersection with a tube support plate. The tube extends through a broached hole that provides support against vibration. To the right is a typical eddy current signal terrain type plot of the tapered tube wear that occurs due to interaction between the tube and the tube support plate.

Steam Generator Tube Support Plate Wear

Benefits

By significantly reducing the number of tubes required to be plugged during an outage, savings are introduced by installing fewer tube plugs and stabilizers (hardware) which reduces dose, contaminated waste, contractor time on-site and the overall SG outage window. Plugging fewer tubes can provide additional SG tube plugging margin allowing for operation at higher main steam line pressures over time. The volume-based engineering model can also be used to technically justify increasing the operating period between SG eddy current inspections, enabling a utility to take full advantage of the plant technical specification allowances including justifying changes to the technical specifications inspection interval limitation, when appropriate. Successful extension of the SG inspection interval is anticipated to have significant financial and outage scheduling benefits.



Shown above is the tube support depth versus volume relation for a typical PWR steam generator. This non-linear relation is typical and leads to improved accuracy in degradation projections.

Tube Support Wear Depth vs. Volume

Deliverables

The SG tube wear volume based predictive model can be fully integrated into the SG tube integrity assessments already required to be performed during an outage inspection. These are the degradation assessment (DA), condition monitoring (CM) and operational assessments (OA).

Application of the SG tube wear volume predictive model can technically support extension of inspection intervals beyond the current plant technical specifications. For plants that desire technical specifications changes, Westinghouse can provide:

- 1) The technical justification for changing mandatory guidance contained within the EPRI Steam Generator Integrity Assessment Guideline Document and NEI 97-06.
- 2) Licensing support for the preparation of the License Amendment Request package for submittal to the Nuclear Regulatory Commission staff.

Experience

Westinghouse has successfully applied the tube wear volume predictive model to domestically operating SGs. In one instance at a plant with recently replaced SGs, it was found that traditional depth-based tube integrity assessments only allowed for two operating cycles between eddy current inspections. As a result of applying the volume-based method, the utility is now capable of operating three cycles between eddy current inspections. This is the maximum duration allowed by the plant technical specifications.

The steam generator tube wear volume predictive model has been patented by Westinghouse under U.S. Patent No. 9,845,950, 2017.