NEI 97-06 [Rev 1]

Steam Generator Program Guidelines

January 2001

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Nuclear Energy Institute

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ACKNOWLEDGMENTS

The Nuclear Energy Institute (NEI) Task Force on Steam Generator Programs developed the *Steam Generator Program Guideline* with oversight provided by the NEI Steam Generator Issues Working Group. We appreciate those industry contributors who reviewed and commented on this document to improve its technical content and its clarity.

NEI also wishes to thank EPRI. EPRI, through the Steam Generator Management Project, developed the steam generator guidelines referenced in this document.

NOTICE

EXECUTIVE SUMMARY

NEI 97-06 establishes a framework for structuring and strengthening existing steam generator programs. It provides the fundamental elements expected to be included in a steam generator program. These elements incorporate a balance of prevention, inspection, evaluation, repair and leakage monitoring measures.

This guideline refers licensees to EPRI guidelines for the detailed development of these programmatic attributes. EPRI will maintain these guidelines through the Steam Generator Management Project consensus process. Revisions to the EPRI documents will follow the protocol as noted in Section 1.5 of this document.

The intent of this document is to bring consistency in application of industry guidelines relative to managing steam generator programs. This document and those it references recognize the need for flexibility within each plant-specific program to adjust for the degree of degradation experienced and expected improvements in techniques for managing tube degradation.

Section 1, "Introduction", provides a background, discusses regulatory interface, licensee responsibilities, and protocol for revision of the referenced EPRI guidelines.

Section 2, "Performance Criteria", defines the performance criteria that licensees shall use to measure tube integrity. Meeting the performance criteria provides reasonable assurance that the steam generator tubing remains capable of fulfilling its intended safety function of maintaining RCPB integrity.

Section 3, "Steam Generator Program", discusses the program elements and implementing guidance for strengthening existing steam generator programs.

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1. Introduction

1.1 PURPOSE

The purpose of this document is to bring consistency in application of industry guidelines related to managing steam generator programs. The framework offered in this document incorporates a balance of prevention, inspection, evaluation, repair and leakage monitoring measures. Additionally, this document establishes performance criteria that licensees shall use under the Maintenance Rule.

1.2 BACKGROUND

The program elements described in this document are evidence of the nuclear industry's commitment to safe and reliable steam generator operation. These elements focus on issues relative to the management and repair of steam generator tubing. For over two decades, the industry has expended considerable resources developing guidance on structuring steam generator programs to meet the challenges posed by tube degradation.

Chemistry control is an example of the industry's commitment to the resolution and management of steam generator degradation. By the mid-1970s, licensees were plugging tubes at a rate that would exceed steam generator 40-year-life design margins. The dominant damage form at that time was tube wastage. The industry corrected this by changing to an all-volatile water chemistry control. This, however, resulted in conditions conducive to corrosion of the carbon steel support plates, which led to tubing deformation as a result of denting and cracking with the same unacceptable rate of tube plugging. The industry, working through EPRI, met these challenges by implementing steam generator programs with aggressive improvements in control of secondary-side water chemistry and upgrades in secondary-side equipment, thus essentially eliminating both wastage and denting. The industry incorporated these successful programmatic strategies in the EPRI *Secondary Water Chemistry Guidelines* and associated supporting documents.

These chemistry guidelines have proven to be the cornerstones of the industry's effort to maintain acceptable steam generator performance. Over time, the industry's steam generator programs have matured to include improvements in programmatic features, such as non-destructive examination, primary-to-secondary leakage monitoring, and degradation-specific management. Building on the collective expertise of the industry, the EPRI Steam Generator Management Project (SGMP) oversees the maintenance of these guidelines, to incorporate technological and programmatic improvements.

1.3 Licensee Responsibilities

Revision 1 of NEI 97-06 was developed to incorporate the improvements identified during the creation of the Steam Generator Generic License Change Package and the resolution of technical issues raised by the NRC since the issuance of Revision 0. Each licensee shall ensure that existing regulatory requirements are met during implementation of NEI 97-06.

Each licensee shall adopt the performance criteria contained in Section 2. The performance criteria are (1) Structural Integrity, (2) Accident-Induced Leakage and (3) Operational Leakage. Further, each licensee shall evaluate existing program elements against those described in Section 3 and revise and strengthen, where necessary, to meet the intent of this document and the referenced EPRI guidelines.

The steam generator program described in this document requires adherence to the intent of both the integrity elements and support elements discussed below.

The integrity and support elements are as follows:

Integrity Elements:
- assessment of potential degradation mechanisms
- inspection
- integrity assessment
- maintenance and repairs
- primary-to-secondary leakage monitoring
- maintenance of secondary-side integrity
- reports to NRC

Support Elements:
- secondary-side water chemistry
- primary-side water chemistry
- foreign material exclusion
- self assessment
- reports to industry

Section 3 provides additional information on these program elements.

1.4 REGULATORY REQUIREMENTS

The following section addresses NRC requirements that licensees should **consider** in the development and implementation of the plant-specific steam generator program.

1.4.1 10 CFR Part 50 Appendix A, *General Design Criteria for Nuclear Power Plants, and Appendix B, Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants.*

General Design Criteria (GDC) 1, 2, 4, 14, 30, 31 and 32 of 10 CFR Part 50, Appendix A, define requirements for the reactor coolant pressure boundary (RCPB) with respect to structural and leakage integrity. Steam generator tubing and tube repairs constitute a major fraction of the RCPB surface area. Steam generator tubing and associated repair techniques and components, such as plugs and sleeves, must be capable of maintaining reactor coolant inventory and pressure.

General Design Criteria (GDC) 19 of 10 CFR Part 50, Appendix A, defines requirements for the control room and for the radiation protection of the operators working within it. Accidents involving the leakage or burst of steam generator tubing comprise a challenge to the habitability of the control room. Steam generator tubing and associated repair techniques and components, such as plugs and sleeves, must be capable of maintaining reactor coolant inventory and pressure in order to prevent excessive leakage and the resulting radiation doses to the control room operator.

Nuclear power plants licensed to operate prior to the effective date of 10 CFR 50, Appendix A (1971) are committed to the Proposed Appendix A to l0 CFR 50, General Design Criteria for Nuclear Power Plants, published in the Federal Register on July 11, 1967, which is similar to 10 CFR 50, Appendix A. Plant specific commitments to the Draft General Design Criteria are defined in the licensing bases for such plants.

10 CFR 50, Appendix B, establishes quality assurance requirements for the design, construction and operation of safety-related components. The pertinent requirements of this appendix apply to all activities affecting the safety-related functions of these components; these include, in part, inspecting, testing, operating and maintaining.

Criteria IX, XI, and XVI of Appendix B apply to the steam generator tube integrity program.

1.4.2 10 CFR § 50.65, *Maintenance Rule*

Under the Maintenance Rule, licensees classify steam generators as risk significant components because they are relied on to remain functional during and after design basis events. The performance criteria in Section 2 of this document shall be used to demonstrate that the condition of the steam generator "is being effectively controlled through the performance of appropriate preventive maintenance" (Maintenance Rule §(a)(2)). This guideline and the referenced EPRI guidelines define a steam generator program that provides the appropriate preventive maintenance that meets the intent of the Maintenance Rule.

Steam generators are to be monitored under §(a)(2) of the Maintenance Rule against industry-established performance criteria. If the performance criteria are not met, a cause determination of appropriate depth shall be done and the results evaluated to determine if goals should be established per §(a)(1) of the Maintenance Rule. NUMARC 93-01 [1] offers guidance for implementing the Maintenance Rule should a licensee elect to incorporate additional monitoring goals beyond the scope of this document.

1.4.3 10 CFR § 50.72, *Immediate Notification Requirements for Operating Nuclear Power Reactors, and § 50.73, Licensee Event Report System*

Failure to meet the performance criteria should be assessed to determine if it results in degradation of safety barriers. If so, the reporting requirements of §50.72 and §50.73 should be reviewed to determine applicability.

1.4.4 10 CFR § 100, *Reactor Site Criteria*

10 CFR § 100 establishes reactor-siting criteria, particularly with respect to the risk of public exposure to the release of radioactive fission products. Accidents involving the leakage or burst of steam generator tubing may comprise a challenge to containment and therefore involve an increased risk of radioactive release. Steam generator tubing and associated repair techniques and components, such as plugs and sleeves, must be capable of maintaining reactor coolant inventory and pressure in order to prevent excessive leakage.

1.4.5 Plant Technical Specifications

Primary-to-Secondary Leakage - Plant technical specifications include a requirement to shut down when primary-to-secondary leakage exceeds an established threshold.

1.5 PREPARATION AND REVISION PROTOCOL FOR EPRI GUIDELINES

The requirements in the EPRI guidelines represent a consensus of the committee and are experience-based in that they are achievable with available technology. Requirements will be incorporated into the EPRI guideline documents when it has been successfully demonstrated that the requirements can be applied in operating plants. Meeting the intent of the EPRI Guidelines (References 2 through 7) is required. While it is recognized that specific site experience and steam generator design may require adaptation of select requirements within the supporting documents, the overall program elements are independent of steam generator design and apply to both first and second generation steam generators.

When a licensee's steam generator program deviates from the applicable guideline, a technical justification for deviation should be written and approved in accordance with the licensee's steam generator program. The technical justification should provide the basis for the determination that the proposed deviation meets the intent established by the applicable documents. Information on justifying deviations is provided in Appendix D.

The responsibility for development and/or revision of EPRI Guidelines is typically assigned to the cognizant EPRI Steam Generator Management Project (SGMP) Issues Resolution Group (IRG) or the Technical Support Subcommittee (TSS).

Draft versions of documents or guidelines are typically generated as part of the interactive process of document development. Whenever possible and appropriate, it is desirable that these documents receive a "broad base" review and therefore the documents are normally distributed to the Technical Advisory Group (TAG) for review.

EPRI Guidelines are approved by the following groups in the order indicated:

1. Guideline or Ad-Hoc Committee responsible for development
2. IRG or TSS assigned oversight responsibility for the document
3. Issues Integration Group (IIG)*
4. Executive Group*

* IIG and Executive Group approval is required for all the guidelines listed in this section except for the *PWR Steam Generator Tube Plug Assessment Document*, [8]; and the *PWR Sleeving Assessment Document* [9].

Additional information on the EPRI SGMP protocol is provided in Reference 11.

The EPRI guidelines referenced herein are:

- *PWR Steam Generator Examination Guidelines* [2];
- *PWR Primary-to-Secondary Leak Guidelines* [3];
- *PWR Secondary Water Chemistry Guidelines* [4];
- *PWR Primary Water Chemistry Guidelines* [5]:
- *Steam Generator Integrity Assessment Guidelines* [6];
- *In Situ Pressure Testing Guidelines* [7];

Additional information on plugging and repair can be found in the following assessment documents:

- *PWR Steam Generator Tube Plug Assessment Document*, [8]; and
- *PWR Sleeving Assessment Document* [9].

At an interval not to exceed two years, the EPRI Nuclear Power Council (NPC) will convene a utility committee(s) to review the applicable EPRI guideline to determine the need for revision.

Committee members include utility personnel, supplemented, as appropriate, by consultants, NSSS vendor and other supplier and/or service vendor personnel, all with equal voting rights. The members will have expertise relevant to the particular area being addressed. These committees are responsible to, and under the charter of, a utility sponsor group that broadly represents the management of the plants to which the prepared guidance is applicable. There will be an EPRI staff member on the committee, usually the chairperson, who will be a non-voting member. The NPC will approve the membership on the committees.

Once the committee prepares a final draft, it is circulated for broad industry review. The committee then resolves all comments generated as a result of the review and prepares a final document to be approved and issued by the sponsor group.

The NEI Steam Generator Review Board should be consulted if questions arise on the interpretation of the EPRI guidelines. Such questions should be addressed and resolved before implementation in the steam generator program. Information on the NEI Steam Generator Review Board is provided in Reference 11.

When NEI 97-06 is revised, licensees will modify their steam generator programs accordingly within 6 months. If the next refueling outage is less than six months away, the licensee may delay incorporating appropriate changes for an additional 3 months. The NEI 97-06 document, or transmittal letter, will provide a listing of sections that have been revised along with the technical basis for the revision.

When an EPRI Guideline is revised, EPRI SGMP will notify NEI who will notify PWR licensees. The SGMP transmittal letter, or the guideline document, will provide a listing of the revised sections of the guideline and the technical basis for each revision to the document's mandatory elements. Licensees will modify their steam generator programs during the time frame specified by EPRI SGMP.

2. PERFORMANCE CRITERIA

The steam generator (SG) tubes in pressurized water reactors have a number of important safety functions. These tubes are an integral part of the reactor coolant pressure boundary (RCPB) and, as such, are relied upon to maintain the primary system's pressure and inventory. As part of the RCPB, the SG tubes are unique in that they are also relied upon as a heat transfer surface between the primary and secondary systems such that residual heat can be removed from the primary system. The SG tubes are also relied upon to isolate the radioactive fission products in the primary coolant from the secondary system.

The steam generator performance criteria identify the standards against which performance is to be measured. Performance criteria used for steam generators shall be based on tube structural integrity, accident-induced leakage, and operational leakage as defined below. Meeting the performance criteria provides reasonable assurance that the steam generator tubing remains capable of fulfilling its specific safety function of maintaining RCPB integrity.

2.1 STRUCTURAL INTEGRITY PERFORMANCE CRITERION

The structural integrity performance criterion is:

> *Steam generator tubing shall retain structural integrity over the full range of normal operating conditions (including startup, operation in the power range, hot standby, and cooldown and all anticipated transients included in the design specification) and design basis accidents. This includes retaining a safety factor of 3.0 against burst under normal steady state full power operation and a safety factor of 1.4 against burst under the limiting design basis accident. Any additional loading combinations shall be included as required by existing design and licensing basis.*

The structural performance criterion is based on ensuring that there is reasonable assurance that a steam generator tube will not burst during normal or postulated accident conditions. Section 3.1.3 of this guideline establishes the essential elements to meet this performance criterion.

The EPRI *Steam Generator Integrity Assessment Guideline* [6] offers guidance for the evaluation methods, required margins and adjustments, and the typical inputs and assumptions used to determine tube integrity. It stresses that the tube integrity assessments account for input variability and uncertainties so as to provide a conservative assessment of the condition of the tubing relative to the performance criteria.

In addition to the safety factor of three (3) for normal steady state operation and 1.4 for accident pressures, the integrity evaluation shall verify that the primary pressure stresses not exceed the yield strength for the full range of normal operating conditions as described in the performance criteria. Additionally, all appropriate loads contributing to combined primary plus secondary stress shall be evaluated so as to ensure that these loads do not significantly reduce the burst pressure for the full range of normal operating conditions including postulated accidents. For example, axial loads due to tube-to-shell temperature differences in once-through steam generator designs during postulated MSLB, or axial loading associated with locked tube supports in recirculating steam generator designs should be addressed to ensure that the types of degradation evaluated are not adversely impacted by these conditions.

2.2 ACCIDENT-INDUCED LEAKAGE PERFORMANCE CRITERION

The accident-induced leakage performance criterion is:

> *The primary to secondary accident induced leakage rate for the limiting design basis accident, other than a steam generator tube rupture, shall not exceed the leakage rate assumed in the accident analysis in terms of total leakage rate for all steam generators and leakage rate for an individual steam generator. Leakage is not to exceed 1 gpm per steam generator, except for specific types of degradation at specific locations where the NRC has approved greater accident-induced leakage as part of a plant's licensing basis. Exceptions to the 1-gpm limit can be applied if approved by the NRC in conjunction with approved alternate repair criteria.*

The pressure and temperature conditions used in the determination of the accident induced leakage rate shall be consistent with the conditions assumed in the accident analysis.

Primary-to-secondary leakage is a factor in the dose releases outside containment resulting from a limiting design basis accident. The potential primary-to-secondary leak rate during postulated design basis accidents must not exceed the offsite radiological dose consequences required by 10 CFR Part 100 guidelines or the radiological consequences to control room personnel required by GDC-19.

In most cases when calculating offsite doses, the safety analysis for the limiting design basis accident assumes 1 gpm primary-to-secondary leakage as an initial condition. Plant specific assumptions for accident-induced leakage are defined in each licensee’s licensing basis.

Probabilistic safety analysis sensitivity studies have shown that severe accident risk is sensitive to certain design basis parameters such as 1 gpm accident induced leakage. Leakage rates greater than 1 gpm per steam generator could possibly cause failure in adjacent tubes under the conditions associated with severe accident scenarios. As a result, leakage greater than a plant’s design basis or 1 gpm per steam generator is not allowed without prior NRC approval.

2.3 Operational Leakage Performance Criterion

The operational leakage performance criterion is:

The RCS operational primary-to-secondary leakage through any one steam generator shall be limited to 150 gallons per day.

The typical design basis accident analysis assumes that primary-to-secondary leakage for all steam generators is 1 gallon per minute or increases to 1 gallon per minute as a result of accident induced stresses. The operational leakage performance criterion establishes a margin to the 1-gpm primary-to-secondary leakage value. Plant specific degradation mechanisms may exist which require a plant to implement reduced operational leakage limits.

The PWR Primary-to-Secondary Leak Guidelines [3] provide reasonable assurance that the operational leakage performance criterion will be met. Measurement and detection methods and associated actions shall adhere to the intent of these guidelines.

The pressure and temperature conditions used in the determination of Operational Leakage shall be consistent with the guidance in the PWR Primary to Secondary Leak Guidelines [3].

3. STEAM GENERATOR PROGRAM

The purpose of a steam generator program is to ensure tube integrity. The program should contain a balance of prevention, inspection, evaluation and repair, and leakage monitoring measures. Licensees shall document the program through plant procedures. The major program elements are discussed below.

3.1 Steam Generator Integrity Elements

The guidance presented in section 3.1, Steam Generator Integrity Elements, is critical to a steam generator program. These elements are intended to ensure steam generator tube structural and leakage integrity is maintained. Observance of these elements is required to implement NEI 97-06 as intended.

3.1.1 Assessment of Degradation Mechanisms

Prior to planned steam generator inspections, licensees shall perform an assessment of existing degradation mechanisms. The assessment shall address the reactor coolant pressure boundary within the steam generator, e.g., plugs, sleeves, tubes and the components that support the pressure boundary, such as secondary-side components. The assessment shall consider operating experience from other similar steam generators. The assessment shall also consider engineering analysis of the degradation mechanisms.

The purpose of the assessment is to identify degradation mechanisms and for each mechanism identified:

- choose techniques to test for degradation based on the probability of detection and sizing capability;
- establish the number of tubes to be inspected;
  - establish the structural limits; and

- establish the flaw growth rate or a plan to establish the flaw growth rate.

The identification of these parameters allows a licensee to establish the inspection or repair criterion before an outage. If a plant identifies a new degradation, or if the measured parameters change, such as growth rate, the plant may need to adjust analytical parameters during an inspection as the condition monitoring or operational assessment dictates.

The assessment of potential degradation mechanisms affects both the inspection and structural components of the program. The inspection component identifies the technique's capability, including detection probability, sizing capability, and measurement uncertainty. It will also identify the sampling strategy. The structural component applies the information gathered from the inspection with flaw growth rate projections to establish the repair limit and/or cycle length.

To conduct an effective inspection, the licensee should integrate the structural and inspection components. EPRI *Steam Generator Integrity Assessment Guidelines* [6] and EPRI *PWR Steam Generator Examination Guidelines* [2] provide guidance for assessment of potential degradation mechanisms.

3.1.2 Inspection

Each licensee shall plan inspections according to the expected tube degradation and follow the inspection guidelines contained in the latest revision of the EPRI *PWR Steam Generator Examination Guidelines* [2].

Some of the important features include:

- sampling using a performance-based approach as supported by the degradation and integrity assessment,

- obtaining the information necessary to develop degradation, condition monitoring and operational assessments,

- qualifying the inspection program by determining the accuracy and defining the elements for enhancing NDE system performance, including technique, analysis, field analysis feedback, human performance and process controls.

3.1.3 Tube Integrity Assessment

Licensees shall assess tube integrity after each steam generator inspection. The assessment willinclude all degradation mechanisms known to exist in the steam generator being evaluated. The purpose of the integrity assessment is to ensure that the performance criteria have been met for the previous operating period (i.e., condition monitoring), and will continue to be met for the next period (i.e., operational assessment). These assessments shall account for all significant uncertainties so as to provide a conservative assessment of the condition of the tubing relative to the performance criteria. Potential significant sources of uncertainty include uncertainties associated with the projected limiting defect or indication size, material properties, and structural model. Conservative assumptions should be employed to account for uncertainties not directly treated in the assessment. The EPRI *Steam Generator Integrity Assessment Guideline* [6] offers guidance for the evaluation methods, margins, and uncertainty considerations used to determine tube integrity.

The choice of an evaluation method to verify tube integrity will depend on the uncertainty surrounding the particular degradation being assessed which can be highly dependent on the availability of data. Licensees may use activities such as in-situ pressure testing or pulling tubes to supplement the tube integrity analysis. Reference 6 provides guidance as to when to conduct in situ pressure testing to address past operating period performance. The EPRI *In Situ Pressure Testing Guidelines* [7] provide guidance on screening criteria for candidate tube selection, as well as for test methods and testing parameters.

If a licensee determines that the structural integrity or accident leakage performance criteria have not been satisfied during the prior operating period, an evaluation of causal factors for failing to meet the criteria shall be performed and corrective measures shall be taken. In this event, the licensee is required to take actions in accordance with plant procedures, including notifying the NRC as applicable.

For an unscheduled inspection due to primary-to-secondary leakage, the tube integrity assessment need only address the degradation mechanism that caused the leak, provided the interval between scheduled inspections is not lengthened.

Normally, licensees shall complete an operational assessment for the next operating period within 90 days after startup. If completion of this assessment is not possible due to the complexity of the analysis within the 90-day period, a preliminary assessment is acceptable as an interim measure. There should be reasonable assurance that the performance criteria will not be exceeded prior to completing the final assessment.

Licensees shall establish tube repair criteria for each active degradation mechanism known to exist in the steam generator being evaluated. Tube repair criteria shall be either the existing technical specification through-wall (TW), depth-based criteria (i.e., 40% TW for most plants), a voltage-based repair limit per Generic Letter 95-05 [12], or other alternate repair criteria (ARC). If licensees choose to develop and implement an ARC, they should follow a steam generator degradation-specific management (SGDSM) strategy. NRC approval is required prior to a plant's initial use of an ARC.

For plants experiencing a damage form or mechanism for which no depth sizing capability exists, tubes identified with such damage are "repaired/plugged-on-detection" and integrity should be assessed. Note: "Repair/plug-on-detection" is considered a subset of the depth-based criterion and is not considered an ARC.

If a risk-based assessment is required, guidance may be found in Regulatory Guide 1.174 [13].

3.1.4 Maintenance, Plugging, and Repairs

Licensees shall qualify and implement plugging and repair methods in accordance with industry standards. The qualification of the plugging and repair techniques shall consider the specific steam generator conditions and mockup testing. The purpose of the plugging and repair is typically to remove degraded tubing from service, thereby redefining the reactor coolant pressure boundary.

Licensees shall clearly identify engineering prerequisites and plant conditions prior to performing the plugging or repair. Process controls shall be identified to ensure proper performance of the plugging and repair including the consideration of post maintenance testing. Additionally, licensees shall perform a pre-service inspection of the plugging or repair consistent with the latest revision of the EPRI *PWR Steam Generator Examination Guidelines* [2].

The EPRI *PWR Steam Generator Tube Plug Assessment Document* [8] and the EPRI *PWR Sleeving Assessment Document* [9] provide further guidance for maintenance and repair of tubing.

New repair methods shall be reviewed and approved by the NRC prior to implementation. New plugging designs or methods do not require prior approval by the NRC.

3.1.5 Primary-to-Secondary Leakage Monitoring

Licensees shall establish primary-to-secondary leakage monitoring procedures in accordance with the intent of the EPRI PWR *Primary-to-Secondary Leak Guidelines* [3] and in accordance with the Operational Leakage criterion contained in section 2.3.

Primary-to-secondary leakage monitoring is an important defense-in-depth measure that assists plant staff in monitoring overall tube integrity during operation. Monitoring gives operators information needed to safely respond to situations in which tube integrity becomes impaired and significant leakage or tube failure occurs. Additionally, operational leakage is an important tool for assessing the effectiveness of a steam generator program. Plants should assess any observed operational leakage to determine if adjustments to the inspection program or integrity assessments are warranted.

Appropriate training shall be provided for personnel who respond to primary-to-secondary leakage events.

3.1.6 Maintenance of Steam Generator Secondary-Side Integrity

Secondary-side steam generator components shall be monitored if their failure could prevent the steam generator from fulfilling its intended safety-related function. The monitoring shall include design reviews, an assessment of potential degradation mechanisms, industry experience for applicability, and inspections, as necessary, to ensure degradation of these components does not threaten tube structural and leakage integrity or the ability of the plant to achieve and maintain safe shutdown.

3.1.7. Reports to the NRC

In addition to the utility-specific technical specification reporting requirements, the following reports are required if the information has not already been reported:

Condition	Reports Required
Results of the steam generator inspection indicate greater than 1% of the inspected tubes in any steam generator exceed the repair criteria.	Submit Condition Monitoring including results of tube pulls and in situ testing within 120 days after the RCS reenters Hot Shutdown conditions.

Condition	Reports Required
Failure to meet a performance criterion discovered during condition monitoring.	Submit an Operational Assessment establishing the basis for the next operating cycle. Assess to determine if a serious degradation of a safety barrier has occurred, if so, it is considered a reportable event - notify the NRC in accordance with the requirements of 50.72 and 50.73
Failure to implement a required plugging or repair discovered while operating	Submit an Operational Assessment establishing the basis for the next operating cycle. Notify the NRC in accordance with the requirements of 50.72 and 50.73

3.2 STEAM GENERATOR SUPPORT ELEMENTS

The guidance presented in section 3.2, Steam Generator Support Elements, is important to a steam generator program. These elements are important to provide for the long term viability of the steam generator. Note that observance of these elements is required to adhere to the intent of NEI 97-06.

3.2.1 Secondary-Side Water Chemistry

Each licensee shall have procedures for monitoring and controlling secondary-side water chemistry to inhibit secondary-side corrosion-induced degradation in accordance with the EPRI *PWR Secondary Water Chemistry Guidelines* [4].

3.2.2 Primary-Side Water Chemistry

Each licensee shall have procedures for monitoring and controlling primary-side water chemistry to inhibit primary-side corrosion-induced degradation in accordance with the EPRI *PWR Primary Water Chemistry Guidelines* [5].

3.2.3 Foreign Material Exclusion

Each licensee shall have procedures to monitor for loose parts and control of foreign objects to inhibit fretting and wear degradation of the tubing. This program should include the attributes below.

3.2.3.1 Secondary-Side Visual Inspection

The program should define when such inspections are to be performed, the scope of inspection, and the inspection procedures and methodology to be used. Loose parts or foreign objects that are found should be removed from the steam generators, unless it is shown by evaluation that these objects will not cause unacceptable tube damage. This evaluation should be maintained as part of the inspection record. Tubes found to have visible damage should be inspected non-destructively and plugged or repaired if the repair criteria are exceeded.

3.2.3.2 Control and Monitoring of Foreign Objects and Loose Parts

The program should include procedures to preclude the introduction of foreign objects into either the primary or secondary side of the steam generator whenever it is opened (e.g., for inspections, repairs, and modifications).

Such procedures should include, as a minimum:

- detailed accountability for all tools and equipment used during an operation;
- appropriate controls and accountability for foreign objects such as eyeglasses and film badges;
- cleanliness requirements; and
- accountability for components and parts removed from the internals of major components (e.g., reassembly of cut and removed components).

Licensees should have alarm response procedures for the loose part monitoring system.

3.2.4 Self Assessment

Licensees shall perform self assessments regarding the steam generator management program. This review shall be performed by knowledgeable utility personnel or a contractor with independent experts selected by the licensee on a periodic basis. An INPO assessment can be used as an adjunct to the self assessment. The self assessment should identify areas for program improvement, along with program strengths. The assessment, or a combination of assessments, shall include all of the essential program elements described in Section 3 above.

3.2.5 Industry Reporting

Industry Reporting includes internal reports that document information within the plant’s Steam Generator Program and external reports intended to be shared with other utilities.

Internal reports include Degradation Assessments, Tube Integrity Assessments, and technical justifications for deviation from SG Program requirements. These reports should be retained as records within the SG Program.

External reports are necessary to share information on degradation mechanisms, NDE technique applications, operating experience, and other items. This experience is shared through the EPRI SGMP and various reports.

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Appendix A

REFERENCES

1. NUMARC 93-01, *Industry Guidelines for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants* *.
2. *PWR Steam Generator Examination Guidelines,* EPRI Report TR-107569 *.
3. *PWR Primary-to-Secondary Leak Guidelines*, EPRI Report TR-104788 *.
4. *PWR Secondary Water Chemistry Guidelines,* EPRI Report TR-102134 *.
5. *PWR Primary Water Chemistry Guidelines*, EPRI Report TR-105714 *.
6. *Steam Generator Integrity Assessment Guideline*, EPRI Report TR-107621 *.
7. *In Situ Pressure Testing Guidelines*, EPRI Report TR-107620 *.
8. *PWR Steam Generator Tube Plug Assessment Document*, EPRI Report TR-109495 *.
9. *EPRI PWR Sleeving Assessment Document*, EPRI Report TR-105962 *.
10. NUREG 0844, *NRC Integrated Program for the Resolution of Unresolved Safety Issues A-3, A-4, and A-5 Regarding Steam Generator Tube Integrity*, (September 1988).
11. *Steam Generator Management Program Administrative Procedures,* Product ID 1000776 *.
12. *Voltage-Based Repair Criteria for Westinghouse Steam Generator Tubes Affected by Outside Diameter Stress Corrosion Cracking,* GL 95-05, (August 3, 1999).
13. *An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis,* Regulatory Guide 1.174, (July 1998).

* Latest revision approved per section 1.5

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Appendix B

LIST OF DEFINITIONS

The following definitions are provided to ensure a uniform understanding of terms used in this guideline.

Accident-induced Leakage

The primary-to-secondary leakage occurring during postulated accidents other than a steam generator tube rupture. This includes the primary-to-secondary leakage existing immediately prior to the accident plus additional primary-to-secondary leakage induced during the accident.

Alternative Repair Criteria(ARC)

Alternative Repair Criteria (ARC) are tube repair criteria that may be implemented for a specific defect type as part of a Steam Generator Degradation Specific Management (SGDSM) program in lieu of the generally applicable depth-based criterion. (Plug on detection is not an ARC).

Burst

The gross structural failure of the tube wall. The condition typically corresponds to an unstable opening displacement (e.g., opening area increased in response to constant pressure) accompanied by ductile (plastic) tearing of the tube material at the ends of the degradation.

Condition Monitoring

A comparison of the as-found inspection results against the performance criteria for structural integrity and accident leakage. Condition monitoring assessment is performed at the conclusion of each operating cycle.

Degradation-Specific Repair Criteria

Repair criteria developed for a specific degradation mechanism and/or location, e.g., a degradation specific repair criteria for ODSCC at tube support plates or for PWSCC at the tube sheet expansion.

Faulted

The state of the steam generator in which the secondary side has been depressurized due to a main steam line break such that protective system response such as main steam line isolation, reactor trip, safety injection, etc., has occurred.

Limiting Design Basis Accident

In the context of steam generator primary-to-secondary pressure boundary integrity, it is the accident that results in either the largest differential pressure across the steam generator tubes for structural considerations or the minimum margin to the applicable dose limits for accident leakage considerations.

Normal Steady State Full Power Operation

The conditions existing during MODE 1 operation at the maximum steady state reactor power as defined in the design or equipment specification. Changes in design parameters such as plugging or sleeving levels, primary or secondary modifications, or T_{hot} should be assessed and included if necessary.

Operational Assessment

Forward looking evaluation of the steam generator tube conditions that is used to predict that the structural integrity and accident leakage performance will be acceptable during the next cycle. The operational assessment needs to consider factors such as NDE uncertainty, indication growth, and degradation-specific repair limits.

Performance Criteria

Criteria to provide reasonable assurance that the steam generator tubing has adequate structural and leakage integrity such that it remains capable of sustaining the conditions of normal operation, including anticipated operational occurrences, design basis accidents, external events, and natural phenomena.

Appendix B (Cont'd)

Primary Stress

The primary stress with respect to the structural integrity performance criteria is the primary membrane stress produced by the internal differential pressure acting on the steam generator reactor coolant pressure boundary.

Probability of Detection (POD)

Probability of Detection (POD) is a measure of NDE performance and is defined as the likelihood that a NDE system will detect a flaw. POD may be expressed as a function of the severity of degradation. For this case, POD is typically calculated by comparing destructive examination results with the predictions of the eddy current inspection (found or missed). Alternatively, POD may be expressed as a fraction of the total population of flaws that would be detected by the NDE system (e.g., POD=0.6 per Generic Letter 95-05 [12]).

Repair Limit

Those NDE measured parameters at or beyond which the tube must be repaired or removed from service by plugging. The repair limit will be determined by either subtracting margins for NDE uncertainty and growth from the structural limit or by conducting a probabilistic analysis.

Secondary Stress

The secondary stresses with respect to the structural integrity performance criteria are those stresses resulting from dynamic loads obtained from the modal analysis of the steam generator and its support structure. Major hydrodynamic and flow induced forces should be considered.

Steam Generator Degradation-Specific Management (SGDSM)

The use of inspection and/or repair criteria developed for a specific degradation mechanism, e.g., outside diameter stress corrosion cracking at tube support plates.

Steam Generator Tubing

Steam generator tubing refers to the entire length of the tube, including the tube wall and any repairs to it, between the tube-to-tube sheet weld at the tube inlet and the tube-to-tube sheet weld at the tube outlet. The tube-to-tube sheet weld is not considered part of the tube.

Appendix C

LIST OF ABBREVIATIONS AND ACRONYMS

ARC	Alternate Repair Criteria
CFR	Code of Federal Regulations
GDC	General Design Criteria
GPD	Gallons Per Day
IIG	EPRI SGMP Issues Integration Group
IRG	EPRI SGMP Issues Resolution Group
INPO	Institute of Nuclear Power Operations
MSLB	Main Steam Line Break
NDE	Non-Destructive Examination
NEI	Nuclear Energy Institute
NRC	Nuclear Regulatory Commission
NSSS	Nuclear Steam Supply System
ODSCC	Outer Diameter Stress Corrosion Cracking
POD	Probability of Detection
PWR	Pressurized Water Reactor
PWSCC	Pressurized Water Stress Corrosion Cracking
RCPB	Reactor Coolant Pressure Boundary
SG	Steam Generator
SGDSM	Steam Generator Degradation Specific Management
SGMP	Steam Generator Management Project
SGTR	Steam Generator Tube Rupture
TAG	EPRI SGMP Technical Advisory Group
TR	Technical Report
TSS	EPRI SGMP Technical Support Subcommittee

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Appendix D

TECHNICAL JUSTIFICATION REQUIREMENTS FOR DEVIATION FROM NEI 97-06 REFERENCED DOCUMENTS

Introduction

NEI 97-06 requires that a utility meet the intent of the referenced EPRI guidelines. These documents contain industry "best practices" and provide guidelines on procedures, testing, and methodology, the intent of which if followed will help assure compliance with the measures. In some cases, these documents delineate specific elements that may consist of control variables or action levels, procedures, processes, or testing that must be explicitly met by the utility to meet the intent of NEI 97-06. The guidelines and information documents are listed at the end of this appendix.

The purpose of this appendix is to identify levels of documentation that must be developed and reside in a steam generator program if deviations are taken from any of the mandatory elements, procedures, testing, methodology, or guidelines presented in the EPRI guidelines referenced in NEI 97-06. As noted above, some of the support documents (e.g., PWR Primary Water Chemistry Guidelines and the PWR Steam Generator Examination Guidelines) contain elements that must be implemented by the utility. These elements are called "mandatory" in this appendix and are discussed in Section 3 of Reference 11. Deviation from these elements require a technical justification in accordance with this appendix. Additionally, it is suggested that deviations from non-mandatory procedures, testing, methodology, or guidelines listed in the guidelines referenced in NEI 97-06 be justified and documented in the utility's steam generator program.

General Considerations

1. When it is determined that a proposed procedure, testing, methodology or guideline will be implemented in a plant's steam generator program which may not be consistent with the mandatory elements documented in the applicable NEI 97-06 referenced guideline, technical justification shall be written and made part of the utility's steam generator program. Note, a utility's steam generator program includes all sub-tier programs such as the chemistry strategic and optimization programs. Alternatively, the justification may be included in one of these sub-tier programs to which it is applicable. Additionally, deviations from the intent of any other procedure, testing, methodology or guideline presented in NEI 97-06 referenced guidelines requires a technical justification which shall be written and approved in accordance with the utility's steam generator program and made part of that program. Deviation from specific elements of NEI 97-06 referenced guidelines, such as procedures, testing, methodology or guidelines, which is not inconsistent with the original intent of these elements, should be documented with justification in the utility's steam generator program.

2. If the deviation deals with an integrity element specified in NEI 97-06, the technical justification shall provide the basis for the determination that the proposed deviation meets the same objective and intent, or level of conservatism exhibited by the performance criteria of NEI 97-06.

3. In no case shall any deviation allow a change to a plant's licensing basis without review and approval required by regulation.

4. To help assure that a thorough review of a deviation and its' justification associated with any procedure, testing, methodology, or guideline documented in NEI 97-06 referenced guidelines is performed, it may be necessary to solicit comments or input from a number of sources. These sources should not always be limited to in-house utility personnel, but other utility/industry experts should be consulted where appropriate. An

appropriate situation for outside review may be that associated with inspection of a degradation mechanism that is first identified in the plant's steam generator and for which a deviation on inspections processes is developed. Additionally, deviations from mandatory elements or intent of the guidelines shall be given this type of review.

5. If the suggested deviation involves an interpretation of any requirement procedure, testing, methodology, or guideline documented in NEI 97-06 referenced guidelines, the NEI Review Board addressing interpretations of NEI 97-06 shall be consulted for assuring the accuracy of the interpretation. Such interpretations should be addressed in this manner and resolved before the deviation involving an interpretation is implemented by approval authority in the steam generator program.

Technical Justification for Deviation Document Structure

1. The subject justification should contain a description and location of the affected requirement.

2. The justification should be explicit in detailing the deviation that is being taken. It should clearly identify what applicable additional information, potential and acceptable impact to the plant, or knowledge is available that allows the deviation to be acceptable. If the deviation deals with an integrity element specified in NEI 97-06, the justification shall demonstrate the deviation maintains the same level of performance criteria required under NEI 97-06.

3. The accompanying justification for the deviation should clearly state how long this deviation will be in force.

4. The justification should clearly identify all applicable site organizations that the deviation may impact in terms of procedures or decision making processes, such as NDE, water chemistry, and operator personnel.

5. The justification or document in which it is contained should clearly identify appropriate approval signatures and dates per the utility's document control procedures.

EPRI guidelines referenced in NEI 97-06 are:

1. PWR Steam Generator Examination Guidelines

2. PWR Primary-to-Secondary Leak Guidelines

3. PWR Secondary Water Chemistry Guidelines

4. PWR Primary Water Chemistry Guidelines

5. Steam Generator Integrity Assessment Guidelines

6. Steam Generator In-Situ Pressure Test Guidelines

Information documents referenced in NEI 97-06 are:

1. PWR Steam Generator Tube Plug Assessment Document

2. EPRI PWR Sleeving Assessment Document