NEI 97-06 [Rev. 3]

Steam Generator Program Guidelines

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Nuclear Energy Institute

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The Nuclear Energy Institute (NEI) Steam Generator Task Force developed the *Steam Generator Program Guidelines* with oversight provided by the NEI Steam Generator Issues Working Group and the Steam Generator Management Project (SGMP) Integration Committee (IC). 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 the Electric Power Research Institute (EPRI). EPRI, through the SGMP, developed the steam generator guidelines referenced in this document.

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REVISION SUMMARY

Revision	Description of Changes
0	Initial issue
1	Most significant changes: • Removed the term "Directive Guidelines" • Reorganized to differentiate between Steam Generator Program "Integrity Elements" and "Support Elements" • Added guidance for justifying deviations from NEI 97-06 and its referenced EPRI Guidelines added • Changes made to the guideline revision protocol including approval, industry notification and the role of the NEI Review Board • Changed the structural integrity and accident induced leakage performance criterion • Changed and clarified the NRC reporting requirements • Added definitions for Burst, Normal Full Power Operations, Limiting Design Basis Accident and Steam Generator Tubing
2	Most significant changes: • Defined and listed the "Mandatory" and "Shall" requirements • Changed the structural integrity and accident induced leakage performance criterion • Added references to the new generic steam generator technical specifications (TSTF-449) • Removed the distinction between Steam Generator Program "Integrity Elements" and "Support Elements" • Delineated management responsibilities for the Steam Generator Program • Reduced the detail in the Degradation Assessment and Integrity Assessment sections and referenced the governing EPRI Guidelines • Added a section on Contractor Oversight • Added information on the NSIAC Steam Generator and Materials Initiatives • Removed guidance for justifying deviations from NEI 97-06 and its referenced EPRI Guidelines. Now included in SGMP Administrative Procedures • Revised the NRC reporting requirements to be consistent with existing licensee technical specifications and the new generic steam generator technical specifications (TSTF-449) • Expanded industry reporting requirements • Added definitions for Collapse, Repair Methods, and Significant Loads and revised the definitions of Primary and Secondary Stress • Reorganized and moved sections 3.7 through 3.12
3	• Removed "shall" requirements as they are all now incorporated in EPRI SGMP Guideline Documents or NEI 03-08 • Corrected inconsistencies with this document and steam generator technical specifications • Corrected the following definitions: Accident Induced Leakage, Normal Steady State Full Power Operation, Operational Assessment, Steam Generator Tubing

EXECUTIVE SUMMARY

NEI 97-06 establishes a framework for structuring and strengthening existing Steam Generator Programs. It provides the fundamental elements to be included in a Steam Generator Program. These elements incorporate a balance of prevention, inspection, evaluation, repair and leakage monitoring measures.

NEI 97-06 and its referenced EPRI guidelines are the documents that define "The Steam Generator Program" referred to in steam generator technical specifications. All US Licensees have changed their technical specifications consistent with NEI 97-06 and its associated regulatory framework.

This document contains “mandatory” requirements consistent with the industry’s Materials Initiative as defined in NEI 03-08, *Guideline for the Management of Materials Issues* [13]. A summary of these requirements is provided in Section 4.

This guideline refers licensees to EPRI Steam Generator guidelines for the detailed development of these programmatic attributes. EPRI maintains these guidelines through the Steam Generator Management Program consensus process.

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 background, discusses regulatory interface, licensee responsibilities, and the EPRI steam generator guidelines.

Section 2, "Performance Criteria", defines the performance criteria that licensees 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 reactor coolant system (RCS) pressure boundary integrity.

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

Section 4, “Summary of Steam Generator Program Requirements”, summarizes the “mandatory” elements contained within NEI 97-06.

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STEAM GENERATOR PROGRAM GUIDELINES

1 INTRODUCTION

1.1 PURPOSE

The purpose of this document is to establish the framework for the Steam Generator Program. The framework offered in this document incorporates a balance of prevention, inspection, evaluation, repair and leakage monitoring measures. Additionally, this document describes performance criteria that define steam generator tube integrity.

This document contains mandatory requirements as defined in NEI 03-08, *Guideline for the Management of Materials Issues* [13]. These requirements are summarized in Section 4.0.

NEI 97-06 is the subject of the industry's Steam Generator Initiative and is also consistent with the intent of the industry's Materials Initiative as defined in NEI 03-08[13]. Every pressurized water reactor (PWR) licensee has established a Steam Generator Program consistent with NEI 97-06.

NEI 97-06 and its referenced EPRI guidelines are the documents that define the Steam Generator Program referred to in steam generator technical specifications.

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 more than 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 cornerstone 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. These and other program elements have been incorporated into a series of EPRI Steam Generator Program Guidelines. Building on the collective expertise of the industry, the EPRI Steam Generator Management Program (SGMP) oversees the maintenance of these guidelines to incorporate technological and programmatic improvements.

Recognizing the importance of steam generators on safe plant operations, NEI 97-06 was developed as a framework for a comprehensive Steam Generator Program that used the EPRI SGMP Guidelines as its technical foundation. The NEI Nuclear Strategic Issues Advisory Committee (NSIAC) used NEI 97-06 as the basis of the following industry initiative on Steam Generator Programs, which was approved on December 16, 1997 [14].

> *"Each licensee will evaluate its existing Steam Generator Program and, where necessary, revise and strengthen program attributes to meet the intent of the guidance provided in NEI 97-06, Steam Generator Program Guidelines, no later than the first refueling outage starting after January 1, 1999."*

In accordance with the NSIAC charter, each PWR licensee is committed to adopt this initiative.

1.3 LICENSEE RESPONSIBILITIES

Each PWR licensee has adopted performance criteria similar to those contained in Section 2 within their plant technical specifications. The performance criteria are (1) Structural Integrity, (2) Accident-Induced Leakage and (3) Operational Leakage. It is mandatory that each PWR licensee establish and maintain a Steam Generator Program consistent with NEI 97-06 and the EPRI guidelines listed in section 1.5.

When NEI 97-06 is revised, NEI distributes the new document to its members. The NEI transmittal letter states the date by which implementation of the revision is required and the importance ("mandatory" or "needed") of completing the implementation by the date specified. The NEI 97-06 document, or transmittal letter, also provides a listing of sections that have been revised along with the technical basis for the revision.

Revision 3 of NEI 97-06 incorporates the improvements identified during the implementation of the Steam Generator Generic License Change Package (TSTF 449) [15] and also addresses changes that have been incorporated into the referenced EPRI guidelines since the issue of revision 2. It is mandatory that every PWR licensee revise its Steam Generator Program consistent with NEI 97-06 Revision 3.

Nuclear station management is responsible for providing sufficient resources for implementation of a Steam Generator Program. Specific management responsibilities include the following:

- Establish and support a utility-managed steam generator management committee that addresses the following functional areas: chemistry, In Service Inspection (ISI)/Non-Destructive Examination (NDE), engineering, quality assurance, planning, health physics, operations, outage management, and maintenance.
- Develop a knowledgeable steam generator organization with sufficient responsibility, authority, and resources to implement the Steam Generator Program.
- Encourage initiative and long-term outlook, with respect to problem solving, within the steam generator engineering organization.
- Support frequent and open interchange of experience and technology with other utilities, nuclear steam supply system (NSSS) vendors, examination vendors, and appropriate industry issue programs, research, and regulatory organizations.
- Establish coordination interfaces between design organizations and the steam generator organization to ensure that plant modifications do not unduly hinder steam generator NDE and repair efforts.

1.4 REGULATORY REQUIREMENTS

The following section addresses NRC requirements that licensees 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 with respect to structural and leakage integrity. Steam generator tubing and tube repairs constitute a major fraction of the RCS pressure boundary 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 are 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. 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 a performance criterion means that degradation of a safety barrier has occurred. The reporting requirements of §50.72 and §50.73 are applicable.

Compliance with the steam generator performance criteria is required by the steam generator tube integrity technical specifications.

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 Alternate Source Term

For plants implementing the alternate source term methodology discussed in Regulatory Guide 1.183, the dose guidelines of 10 CFR 100 do not apply. Instead, 10 CFR 50.67 provides the dose guidelines for analyses performed using the alternate source term methodology.

1.4.6 Plant Technical Specifications

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

In addition, the technical specifications include specific requirements for steam generator tube integrity and Steam Generator Programs. The bases for the steam generator technical specifications use NEI 97-06 and its associated guidelines as references for "The Steam Generator Program."

1.5 EPRI STEAM GENERATOR GUIDELINES

The requirements in the EPRI guidelines represent a consensus of the steam generator industry and are experience-based in that they are achievable with available technology. Preparation and approval of all EPRI Steam Generator Guidelines is governed by Reference 10.

EPRI Guidelines form the basis of Steam Generator Program requirements. The following 6 guidelines describe acceptable methods for Steam Generator Programs of PWR licensees:

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

The above guidelines contain “mandatory” and/or “needed” elements as defined in NEI 03-08 [13].

From time to time, new conditions may arise that change guideline requirements or that are not addressed within the guidelines. In these cases, the SGMP may issue Interim Guidance Letters [10]. The requirements in Interim Guidance Letters are identified as "mandatory" or "needed" in the same manner as the guidelines.

While it is recognized that specific site experience and steam generator design may require adaptation of select requirements within the referenced EPRI Steam Generator Guidelines, 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 "mandatory" or "needed" requirements in the applicable guideline, a technical justification for deviation is required by NEI 03-08 [13].

When an EPRI Guideline is revised or interim guidance is issued, SGMP notifies PWR licensees and designates an implementation timeframe.

NEI or the SGMP submit revisions to NEI 97-06, its referenced EPRI Guidelines, review board interpretations and interim guidance to the NRC for information.

2 PERFORMANCE CRITERIA

Tubes in the steam generators of pressurized water reactors perform a number of important safety functions. The tubes are an integral part of the reactor coolant pressure boundary and, as such, are relied upon to maintain the primary system's pressure and inventory. As part of the RCS pressure boundary, the steam generator 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 steam generator 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 are based on tube structural integrity, accident-induced leakage, and operational leakage as defined in plant technical specifications and are repeated below. Meeting the performance criteria provides reasonable assurance that the steam generator tubing remains capable of fulfilling its specific safety function of maintaining RCS pressure boundary integrity.

2.1 STRUCTURAL INTEGRITY PERFORMANCE CRITERION

A plant specific structural integrity performance criterion is included in the technical specifications. For reference, the criterion from the steam generator generic license change package is included below.

"All in-service steam generator tubes shall retain structural integrity over the full range of normal operating conditions (including startup, operation in the power range, hot standby, cool down 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 primary-to-secondary pressure differential and a safety factor of 1.4 against burst applied to the design basis accident primary-to-secondary pressure differentials. Apart from the above requirements, additional loading conditions associated with the design basis accidents, or combination of accidents in accordance with the design and licensing basis, shall also be evaluated to determine if the associated loads contribute significantly to burst or collapse. In the assessment of tube integrity, those loads that do significantly affect burst or collapse shall be determined and assessed in combination with the loads due to pressure with a safety factor of 1.2 on the combined primary loads and 1.0 on axial secondary loads."

The structural integrity performance criterion is based on ensuring that there is reasonable assurance that a steam generator tube will not burst during normal operation or postulated accident conditions. Section 3.3 of this guideline establishes the essential elements to meet this performance criterion.

The EPRI *Steam Generator Integrity Assessment Guidelines* [6] offer 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.

2.2 ACCIDENT-INDUCED LEAKAGE PERFORMANCE CRITERION

A plant specific accident-induced leakage performance criterion is included in the technical specifications. For reference, the criterion from the steam generator generic license change package is included below.

> *The primary to secondary-accident induced leakage rate for any 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 when implementing alternate repair criteria as documented in the Steam Generator Program technical specifications.*

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 are governed by the offsite radiological dose consequences required by 10 CFR Part 100 guidelines or the radiological consequences to control room personnel required by GDC-19, or other NRC-approved licensing bases.

Plant-specific assumptions for accident analyses (e.g., flow rate, pressure, and temperature conditions) are defined in each licensee's licensing basis. There are several accidents that assume primary-to-secondary leakage (e.g., locked rotor, main steam line break). The amount of leakage assumed during each accident can vary. In addition, the loads (pressure and non-pressure loads) imposed on the tubes during these events vary.

NRC probabilistic safety analysis sensitivity studies have shown that severe accident risk may be sensitive to certain design basis parameters such as 1 gpm accident induced leakage. As a result, leakage greater than a plant's design basis or 1 gallon per minute per steam generator is not allowed without prior NRC approval.

2.3 OPERATIONAL LEAKAGE PERFORMANCE CRITERION

A plant specific operational leakage performance criterion is included in the technical specifications. For reference, the criterion from the steam generator generic license change package is included below.

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

The operational leakage performance criterion is consistent with the primary-to-secondary leakage limit in the RCS Operational Leakage technical specification.

The operational leakage performance criterion provides a defense-in-depth added margin against tube rupture under accident conditions with resulting larger margins against rupture under normal operating conditions. Plant-specific degradation mechanisms may exist which requires 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.

3 STEAM GENERATOR PROGRAM

The purpose of a Steam Generator Program is to ensure tube integrity. The program contains a balance of prevention, inspection, evaluation and repair, and leakage monitoring measures. NEI 97-06 and its referenced EPRI guidelines are the documents that define The Steam Generator Program referred to in steam generator technical specifications. It is mandatory that licensee Steam Generator Programs address:

- Degradation assessment
- Inspection
- Integrity assessment
- Tube plugging and repairs
- Primary-to-secondary leak monitoring
- Maintenance of secondary side integrity
- Secondary side water chemistry
- Primary side water chemistry
- Foreign material exclusion
- Contractor oversight
- Self assessment
- Reporting

Further information on each of these topics is provided in sections 3.1 to 3.12 below.

3.1 DEGRADATION ASSESSMENT

Prior to the pre-service and subsequent planned steam generator inspections, licensees perform a Degradation Assessment. The assessment addresses 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 considers operating experience. EPRI *Steam Generator Integrity Assessment Guidelines* [6] provides an acceptable method of performing Degradation Assessments.

The overall purpose of the Degradation Assessment is to ensure that appropriate inspections are performed during the upcoming outage, and that the requisite information for integrity assessment is provided. Some of the important features of the Degradation Assessment include:

- Identifying existing and potential degradation mechanisms
- Choosing techniques to test for degradation based on the probability of detection and sizing capability

- Establishing the number of tubes to be inspected
- Establishing the tube integrity limits for condition monitoring and operational assessment

3.2 INSPECTION

Each licensee plans and conducts inspections according to the Degradation Assessment and follows the inspection guidance contained in the EPRI *PWR Steam Generator Examination Guidelines* [2].

Some of the important features of steam generator tube inspections include:

- Sampling as supported by the degradation 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

3.3 INTEGRITY ASSESSMENT

Licensees assess tube integrity after each steam generator tube inspection. The assessment includes:

- Condition Monitoring – A backward-looking assessment which confirms that adequate steam generator tube integrity has been maintained during the previous inspection interval
- Operational Assessment – A forward-looking assessment which demonstrates that the tube integrity performance criteria will be met throughout the next inspection interval

These assessments accounts for uncertainties to provide a conservative assessment of the condition of the tubing relative to the performance criteria. Licensees follow the guidance contained in the EPRI *Steam Generator Integrity Assessment Guidelines* [6] for determining the evaluation methods and uncertainty considerations used to evaluate tube integrity.

Licensees may use activities such as in-situ pressure testing or pulling tubes as a direct means of verifying that performance criteria have been satisfied. Licensees follow the guidance contained in the EPRI *Steam Generator In Situ Pressure Test Guidelines* [7] for screening and selecting candidate tubes, 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, in accordance with the licensee corrective action program, is performed. In this event, the licensee takes actions in accordance with plant technical specifications, including notifying the NRC as applicable. If a risk-based assessment is necessary, guidance may be found in Regulatory Guide 1.174, *An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific*

Changes to the Licensing Basis [12]. Note that a risk based approach is not allowed by current technical specifications as of the date of this revision. Using this approach would require NRC approval.

3.4 STEAM GENERATOR TUBE PLUGGING AND REPAIRS

Licensees qualify and implement plugging and repair methods in accordance with industry standards. The qualification of the plugging and repair techniques considers the specific steam generator conditions and mockup testing. Repair methods are those means used to reestablish the RCS pressure boundary integrity of steam generator tubes without removing the tube from service. Plugging a steam generator tube is not a repair. The purpose of a repair is typically to reestablish or replace the reactor coolant pressure boundary; a plug removes a tube from service.

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

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

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

3.5 PRIMARY-TO-SECONDARY LEAK MONITORING

Licensees establish primary-to-secondary leak monitoring procedures in accordance with the EPRI PWR *Primary-to-Secondary Leak Guidelines* [3] and in accordance with technical specifications.

Primary-to-secondary leak 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 assess any observed operational leakage to determine if adjustments to the inspection program or integrity assessments are warranted.

3.6 MAINTENANCE OF STEAM GENERATOR SECONDARY-SIDE INTEGRITY

Secondary-side steam generator components that are susceptible to degradation are monitored if their failure could prevent the steam generator from fulfilling its intended safety-related function. The monitoring includes 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. Additional guidance is provided in the EPRI *Steam Generator Integrity Assessment Guidelines* [6].

3.6.1 Secondary-Side Visual Inspection

The program defines when secondary-side visual inspections are to be performed, the scope of inspection, and the inspection procedures and methodology to be used. Additional guidance on secondary side inspections is provided in the *Steam Generator Integrity Assessment Guidelines* [6].

3.7 SECONDARY-SIDE WATER CHEMISTRY

Each licensee has 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].

3.8 PRIMARY-SIDE WATER CHEMISTRY

Each licensee has 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].

3.9 FOREIGN MATERIAL EXCLUSION

3.9.1 Control and Monitoring of Foreign Objects and Loose Parts

The program includes 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, maintenance, repairs, and modifications).

Such procedures include, as a minimum:

- Detailed accountability for all tools and equipment used during any activity when the primary or secondary side is open
- Appropriate controls and accountability for foreign objects such as eyeglasses and personal dosimetry
- Cleanliness requirements
- Accountability for components and parts removed from the internals of major components (e.g., reassembly of cut and removed components)

The potential for introduction of loose parts or foreign objects from secondary-side systems is also considered.

3.10 CONTRACTOR OVERSIGHT

The licensee performs oversight of contracted work. When the licensee contracts portions of the Steam Generator Program work scope, the responsibility for program implementation and compliance with requirements always remains with the licensee. It is the licensee's responsibility to plan, direct, and evaluate all steam generator activities. It is imperative that the licensee oversee not only the contractual, but also the technical aspects of any contracted work. Critical aspects of this oversight include but are not limited to the following:

- Review and approve the scope of work to be performed by a contractor
- Review and approval of the Degradation Assessment
- Review and approval of the contractor's examination procedures
- Monitoring of the contractor's examination work progress
- Review and approval of the contractor's deliverables
- Review and approval of the tube integrity assessment (CM/OA) and associated support documents

3.11 SELF-ASSESSMENT

Licensees perform self-assessments of their Steam Generator Program. This review is performed by knowledgeable utility personnel or a contractor with independent experts selected by the licensee on a periodic basis. An INPO steam generator review visit can be used in lieu of the self-assessment. The self-assessment identifies areas for program improvement, along with program strengths. The assessment, or a combination of assessments, includes all the major program elements described in Section 3.

3.12 REPORTING

3.12.1 Reports to the NRC

NRC reporting by licensees is specified in plant technical specifications.

3.12.2 Non-Regulatory Reports

Non-regulatory reports include internal reports that document information within the plant's Steam Generator Program and external reports intended to be shared with other utilities.

3.12.3 Internal Reports

Internal reports include Degradation Assessments, tube integrity assessments, NDE results, and results of self-assessments. Internal reports are retained in accordance with plant requirements.

3.12.3.1 External Reports

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 through various reports. Reports are submitted to the EPRI SGMP on the following items:

- Any confirmed tube degradation of a type or in a location that has not been previously experienced in a U.S. steam generator
- In situ tests that result in leakage or burst
- NDE and metallurgical data on any pulled steam generator tubes
- Any approved technical justifications for deviation from NEI 03-08, or NEI 97-06 and its referenced EPRI Guidelines
- Any significant steam generator operating experience that has generic implications for the industry
- Steam generator inspection results (submitted to the EPRI SGMP through timely updating of the Steam Generator Degradation Database)

Detailed reporting requirements are contained in the governing EPRI SGMP guidelines.

4 SUMMARY OF STEAM GENERATOR PROGRAM REQUIREMENTS

The following table summarizes the mandatory elements contained within this document.

Category	Section	Requirement
Mandatory	**1.3**	**It is mandatory that each PWR licensee establish and maintain a Steam Generator Program consistent with NEI 97-06 and the referenced EPRI guidelines.**
Mandatory	**1.3**	**It is mandatory that every PWR licensee revise its Steam Generator Program consistent with NEI 97-06 Revision 3.**
Mandatory	**3.0**	**It is mandatory that licensee Steam Generator Programs address:** • **Degradation assessment** • **Inspection** • **Integrity assessment** • **Tube plugging and repairs** • **Primary-to-secondary leak monitoring** • **Maintenance of secondary side integrity** • **Secondary side water chemistry** • **Primary side water chemistry** • **Foreign material exclusion** • **Contractor oversight** • **Self assessment** • **Reporting**

APPENDIX A

REFERENCES

1. NUMARC 93-01, *Industry Guidelines for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants*

2. *Steam Generator Management Program: Pressurized Water Reactor Steam Generator Examination Guidelines**

3. *PWR Primary-to-Secondary Leak Guidelines**

4. *Pressurized Water Reactor Secondary Water Chemistry Guidelines**

5. *Pressurized Water Reactor Primary Water Chemistry Guidelines**

6. *Steam Generator Management Program: Steam Generator Integrity Assessment Guidelines**

7. *Steam Generator In Situ Pressure Test Guidelines**

8. *PWR Steam Generator Tube Plug Assessment Document*, EPRI Report TR-109495

9. *PWR Steam Generator Sleeving Assessment Document Revision 1,* EPRI Report TR-105960-R1

10. *Steam Generator Management Program: Administrative Procedures**

11. *Voltage-Based Repair Criteria for Westinghouse Steam Generator Tubes Affected by Outside Diameter Stress Corrosion Cracking,* GL 95-05 *(*August 3, 1995)

12. *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)

13. NEI 03-08, [Rev 2], *Guideline for the Management of Materials Issues, January 2010*

14. NEI Letter to NSIAC, December 16, 1997, Approval of Formal Industry Position on NEI 97-06, Rev. 0, *Steam Generator Program Guidelines*

15. Technical Specification Task Force letter to the NRC (TSTF 05-05), dated April 14, 2005, TSTF-449, Revision 4, "Steam Generator Tube Integrity"

** Latest published and in-force revision approved by the SGMP*

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 rate existing immediately prior to the accident plus additional primary-to-secondary leakage induced during the accident. Typical accidents with assumed leakage are the steam line break accident, the rod ejection accident, and the locked rotor accident.

Alternate Repair Criteria (ARC)

Alternate 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.

Collapse

For the load displacement curve for a given structure, collapse occurs at the top of the load versus displacement curve where the slope of the curve becomes zero.

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 when a tube is inspected, plugged, or repaired.

Normal Steady State Full Power Operation

The conditions existing during MODE 1 operation at normal steady state full power operation.

Operational Assessment

Forward looking evaluation of the steam generator tube conditions that is used to ensure that the structural integrity and accident leakage performance criteria will not be exceeded during the next inspection interval. The operational assessment needs to consider factors such as NDE uncertainty, indication growth, and degradation-specific repair limits.

Performance Criteria

Criteria that 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.

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 [11]).

Repair Criteria

Those NDE measured parameters at or beyond which the tube must be repaired using an approved repair method or removed from service by plugging.

Repair Methods

Those means used to re-establish the RCS pressure boundary integrity of steam generator tubes without removing the tube from service. Plugging a steam generator tube is not a repair.

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

Unless otherwise defined by technical specifications (i.e., Alternate Repair Criteria), steam generator tubing refers to the entire length of the tube, including the tube wall and any repairs to it, between the tube-to-tubesheet weld at the tube inlet and the tube-to-tubesheet weld at the tube outlet. The tube-to-tubesheet weld is not considered part of the tube.

APPENDIX C

LIST OF ABBREVIATIONS AND ACRONYMS

ARC	Alternate Repair Criteria
CFR	Code of Federal Regulations
CM	Condition Monitoring Assessment
EPRI	Electric Power Research Institute
GDC	General Design Criteria
INPO	Institute of Nuclear Power Operations
NDE	Non-Destructive Examination
NEI	Nuclear Energy Institute
NRC	Nuclear Regulatory Commission
NSSS	Nuclear Steam Supply System
OA	Operational Assessment
POD	Probability of Detection
PWR	Pressurized Water Reactor
RCS	Reactor Coolant System
SGMP	Steam Generator Management Project