NUCLEAR ENERGY INSTITUTE

Alex Marion
DIRECTOR, ENGINEERING
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September 24, 2003

Dr. Brian W. Sheron
Associate Director for Project Licensing and Technical Analysis
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Mail Stop O5-E7
Washington, DC 20555-00011

SUBJECT: Industry Steam Generator Management Project - New Guidance

PROJECT NUMBER: 689

Dear Dr. Sheron:

The Steam Generator Management Project (SGMP) has issued revision 2 to its Steam Generator In Situ Pressure Test Guidelines. In addition, the SGMP has issued an interim guidance letter on the Three Mile Island (TMI) tube sever event. Copies of these documents are enclosed for your information. Your endorsement of this material is not requested.

The guidelines in Enclosure 1 contain proprietary information that is supported by the signed affidavit in Enclosure 2. The affidavit sets forth the basis on which the information may be withheld from public disclosure by the Commission and addresses with specificity the consideration listed in paragraph (b)(4) of Section 2.790 of the Commission's regulations. Accordingly, we respectfully request that the information, which is proprietary to EPRI, be withheld from public disclosure in accordance with 10 CFR 2.790. Copies of the non-proprietary version of the In Situ guidelines are included in Enclosure 3.

The TMI tube sever interim guidance letter is included in Enclosure 4.

If there are any questions on these matters, please contact Jim Riley at 202-739-8137 of jhr@nei.org.

Sincerely,

Alex Marion

Alex Marion

Enclosures

c: Ms. Louise Lund, NRC (w/ enclosure)
Mr. Emmett Murphy, NRC (w/o enclosure)
Mr. Ken Karwoski, NRC (w/o enclosure)
Mr. Brian Benney, NRC (w/o enclosure)

ELECTRIFY THE WORLD

EPRI

September 11, 2003

Document Control Clerk
U.S. Nuclear regulatory Commission
OWN 11555 Rockville Pike
Washington DC, 20555

Subject: "Steam Generator In Situ Pressure Test Guidelines, Revision ,2, EPRI Report 1007904, August 2003.

Gentlemen:

This is a request under 10CFR2.790(a)(4) that the NRC withhold from public disclosure the information identified in the enclosed affidavit consisting of EPRI owned Proprietary Information identified above (the "Report"). Copies of the Report and the affidavit in support of this request are enclosed.

EPRI desires to disclose the Report in confidence to the NRC as a means of exchanging information in support of generic regulatory improvements relating to NEI 97-06, "Steam Generator Program Guidelines." Further, EPRI welcomes any discussion with the NRC regarding the Report that the NRC desires to conduct.

The Report is for the NRC's internal use and may be used only for the purposes for which it is disclosed by EPRI. The report should not be otherwise used or disclosed to any person outside the NRC without prior written permission from EPRI.

If you have any questions about the legal aspects of this request for withholding, please do not hesitate to contact me at (650) 855-2340. Questions on the contents of the Report should be directed to Mohamad M. Behravesh of EPRI at (650) 855-2388.

Sincerely,

Warren J. Bilanin

Warren J. Bilanin.
Director, Nuclear Power Sector

Enclosures (1)

Cc: Licensing
Jim Riley / NEI

EPRI

AFFIDAVIT

RE: "Steam Generator In Situ Pressure Test Guidelines, Revision 2" EPRI Report 1007904, August 2003.

I, WARREN J. BILANIN, being duly sworn, depose and state as follows:

I am a Director at the Electric Power Research Institute ("EPRI") and I have been specifically delegated responsibility for the report listed above that is sought under this affidavit to be withheld (the "Report") and authorized to apply for their withholding on behalf of EPRI. This affidavit is submitted to the Nuclear Regulatory Commission ("NRC") pursuant to 10 CFR 2.790 (a)(4) based on the fact that the Report consists of trade secrets of EPRI and that the NRC will receive the Report from EPRI under privilege and in confidence.

The basis for withholding such Report from the public is set forth below:

(i) The Report has been held in confidence by EPRI, its owner. All those accepting copies of the Report must agree to preserve the confidentiality of the Report.

(ii) The Report is a type customarily held in confidence by EPRI and there is a rational basis therefor. The Report is a type, which EPRI considers as a trade secret(s) and is held in confidence by EPRI because to disclose it would prevent EPRI from licensing the Report at fees, which would allow EPRI to recover its investment. If consultants and/or other businesses providing services in the electric/nuclear power industry were able to publicly obtain the Report, they would be able to use it commercially for profit and avoid spending the large amount of money that EPRI was required to spend in preparation of the Report. The rational basis that EPRI has for classifying this/these Report(s) as a trade secrets is justified by the Uniform Trade Secrets Act, which California adopted in 1984 and which has been adopted by over twenty states. The Uniform Trade Secrets Act defines a "trade secret" as follows:

> "Trade secret" means information, including a formula, pattern, compilation, program, device, method, technique, or process, that:
>
> (1) Derives independent economic value, actual or potential, from not being generally known to the public or to other persons who can obtain economic value from its disclosure or use; and
>
> (2) Is the subject of efforts that are reasonable under the circumstances to maintain its secrecy.

(iii) The Report will be transmitted to the NRC in confidence.

EPRI

(iv) The Report is not available in public sources. EPRI developed the Report only after making a determination that the Report was not available from public sources. It required a large expenditure of dollars for EPRI to develop the Report. In addition, EPRI was required to use a large amount of time of EPRI employees. The money spent, plus the value of EPRI's staff time in preparing the Report, show that the Report is highly valuable to EPRI. Finally, the Report was developed only after a long period of effort of at least several months.

(v) A public disclosure of the Report would be highly likely to cause substantial harm to EPRI's competitive position and the ability of EPRI to license the Report both domestically and internationally. The Report can only be acquired and/or duplicated by others using an equivalent investment of time and effort.

I have read the foregoing and the matters stated therein are true and correct to the best of my knowledge, information and belief. I make this affidavit under penalty of perjury under the laws of the United States of America and under the laws of the State of California.

Executed at 3412 Hillview Avenue, Palo Alto, being the premises and place of business of the Electric Power Research Institute:

September 11, 2003

Warren T Bilanin

Warren J. Bilanin

Subscribed and sworn before me this day: September 11, 2003

Sumi Yamashita

Sumi Yamashita, Notary Public

SUMI YAMASHITA
COMM. # 1255539
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SANTA CLARA COUNTY
COMM. EXP. MARCH 31, 2004

Enclosure 4

TMI Tube Sever Event

Interim Guidance Letter

Pacific Gas and
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August 18, 2003

To: Steam Generator Management Program (SGMP) Utility Steering Committees
PMMP Steering Committee
Senior Representatives
Technical Advisory Group (TAG)

From: Lawrence F. Womack
Chair, Steam Generator Management Program

Subject: Interim Guidance on Three Mile Island Tube Sever Event

Background

During the fall of 2001, eddy current inspections of steam generator (SG) tubes at Three Mile Island (TMI)-1 and Oconee Nuclear Station (ONS)-1 revealed wear scars on tubes surrounding previously plugged tubes. In both cases, it was determined that the plugged tubes had severed and impacted neighboring tubes. As a result, the NRC issued Information Notice IN2002-2, which suggested that the industry investigate the issue of plugged tubes damaging neighboring tubes on a generic basis and identify possible recommendations. EPRI contracted Framatome ANP and Westinghouse to assess the issue for once-through steam generators (OTSGs) and recirculating steam generators (RSGs), respectively (EPRI Report 1008438, dated May 2003).

Interim Guidance

Steam generator tubes removed from service by plugging are no longer inspected for degradation initiation or growth. This interim guidance letter highlights the recommendations from the generic study undertaken to identify those areas of the steam generator where propagation of degradation could lead to tube sever and thus impact neighboring in-service tubes.

Requirements

For all SG designs, utilities shall review the cross-functional effects of chemistry excursions and intrusions in addition to loose parts and foreign material on plugged tubes along with in-service tubes.

For Recirculating Steam Generators:

1. An initiative to remove from service (by deplugging or repairing) all plugs made from Alloy 600 should continue, and those that remain in service shall be inspected for cracking.
2. Unless the results of a stabilization analysis conclude otherwise, all tubes with circumferential cracks within the expansion transition region or within 0.5" of the top of tubesheet shall be stabilized. Analysis shall include the effects of the tube being locked at the first tube support plate and the potential for continued growth of degradation.

3. When plugging for AVB wear, analysis shall consider post-plugging growth to determine the need to stabilize. For tubes plugged early in life for significant AVB wear and not stabilized, an analysis shall be performed to determine if the tubes should be deplugged and stabilized, if adjacent in-service tubes should be plugged, or if bobbin coil monitoring of adjacent in-service tubes is sufficient.
4. Tubes plugged for preheater wear that have been evaluated as part of the preheater wear issue resolution do not have a potential for tube severance; however, in lieu of an analysis to determine the need for stabilization, stabilization is required.

For Once-Through Steam Generators:

1. For OEM-plugged tubes, apply stabilization criteria assuming a volumetric 100% through wall flaw in the upper span. Deplug and stabilize or stabilize and plug downstream flanking tubes as required by stabilization criteria.
2. Plugged tubes with potential for swelling, which includes tubes with repaired plugs or replaced UTS plugs, shall be deplugged, inspected, and stabilized or downstream flanking tubes shall be stabilized and plugged.
3. Tubes plugged in the lower tube end but open in the upper tube end, and tube pull locations with an open top end, require monitoring of adjacent tubes for wear in the freespan
4. Any indications of wear outside the TSPs in the freespan shall be investigated for possible tube-to-tube wear due to a severed tube.
5. If possible, stuck probe debris shall be removed at the next outage and the tube dewatered and inspected prior to replugging. Monitoring adjacent tubes for wear in the freespan is an acceptable alternative.
6. Plugged tubes in the lane region that have not been sleeved or stabilized shall be deplugged, inspected, and stabilized in the top spans or adjacent downstream and flanking tubes shall be plugged and stabilized in the top spans. This tube population in the OTSGs is also addressed by plugged tubes that have been repaired (recommendation No. 2).

This interim guidance is effective six months from the date of this letter. If a plant has a scheduled refueling outage within the six-month period, then nine months are allowed for implementation.

Sincerely,

Lawrence F. Womack
Vice President, Nuclear Services – Diablo Canyon Power Plant
Chair, SGMP PMMP Steering Committee

cc Jim Riley – NEI
Jeff Ewin – INPO
David Steininger – EPRI
Mohamad Behravesh - EPRI

Enclosure 3

Steam Generator In Situ Pressure Test Guidelines

Revision 2

Non-Proprietary Version

Non-Proprietary Version

Steam Generator In Situ Pressure Test Guidelines

Revision 2

EPRI Technical Report 1007904

August 2003

EPRI Project Managers

M. Behravesh

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Non-Proprietary Version

Steam Generator In Situ Pressure Test Guidelines

Revision 2

EPRI Technical Report 1007904

August 2003

EPRI Project Managers

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ORGANIZATION(S) THAT PREPARED THIS DOCUMENT

Engineering and Regulatory Issues Resolution Group

ORDERING INFORMATION

Requests for copies of this report should be directed to EPRI Orders and Conferences, 1355 Willow Way, Suite 278, Concord, CA 94520, (800) 313-3774, press 2 or internally x5379, (925) 609-9169, (925) 609-1310 (fax).

CITATIONS

This report was prepared by

Engineering and Regulatory Issues Resolution Group
Street Address
City, State Zip

This report describes research sponsored by EPRI.

The report is a corporate document that should be cited in the literature in the following manner:

Steam Generator In Situ Guidelines, EPRI, Palo Alto, CA: 2003. 1007904.

REPORT SUMMARY

Information in this document provides guidance for the performance of in situ pressure testing of steam generator tubes. In situ pressure testing refers to hydrostatic pressure tests performed on installed tubing in the field. Such testing is considered a direct means of evaluating tube structural and leakage integrity. In situ pressure testing can be used to support condition monitoring and operational assessments of steam generator tube integrity, and can provide supplemental information in support of burst and leak correlations.

Background

Degradation of steam generator tubing can lead to a decrease in the load bearing capacity of the tubes and may compromise pressure boundary leak tightness. When such degradation is found during steam generator inspections, evaluations are performed to ensure that required structural margins are maintained and that leakage, if it occurs during normal operation or during design basis accident events, remains within allowable limits. Structural integrity and leak rate evaluations may be based on in situ proof and/or leak testing of sections of tubing with eddy current indications of degradation. Since this testing allows for the direct measurement of structural and leakage conditions, the results provide a key element in the assessment of steam generator tubing structural and leakage integrity.

Objectives

- To document standard approaches and to provide requirements for the performance of in situ pressurization tests and the application of this test data. This document summarizes industry practices used successfully in the field via a recommended test protocol. Standardization will promote industry wide consistency in test performance and the application of the results.
- To supplement the condition monitoring and operational assessment process as required by NEI 97-06, *Steam Generator Program Guidelines* [1] and described in the EPRI *Steam Generator Integrity Assessment Guidelines* [2].

Approach

The scope of this document includes information regarding tooling qualification, testing procedures, and the selection of tubes for testing. Appendices of this document provide details for a statistical approach for selection of tubes for testing and bases and supporting data for technical sections. All three US steam generator vendors were contacted for input to this document and/or review of its initial development. Additionally, a number of utility personnel who have used in situ pressure testing provided information in support of the document.

Information in this guideline is designed to complement the EPRI guideline for laboratory burst and leak rate testing of steam generator tubing [3].

Results

This document has been developed to institute standard approaches to the performance of in situ pressurization tests. This document contains guidelines on test objectives, test conditions, post test requirements, procedural specifications, and degradation screening criteria for proof and leak evaluation by in situ pressure testing. This guideline is not expected to cover all degradation forms, plant licensing and design bases, tooling designs, or test objectives. Plant or design specific information may be used to deviate from or supplement this guidance. Appropriate technical justification for deviations shall be developed and maintained by the utility. It is a requirement that the utility provide test results to the EPRI Steam Generator Degradation Database for the continued evolution of this guideline.

EPRI Perspective

Condition monitoring and operational assessment of steam generator tubing during a plant outage is a requirement of NEI 97-06. A useful tool in satisfying the requirements of condition monitoring and operational assessment of steam generator tube integrity is the application of in situ pressure test results. The publication of this document represents the best industry practices to date, and later revisions are expected as experience is gained in the application of the guidance contained in this document.

Keywords

Nuclear steam generators
Pressure tests
Condition Monitoring
Operational Assessment

ABSTRACT

A group of industry experts in structural and leakage integrity of steam generator tubing developed guidance for integrity verification by in situ pressure test. This document, together with the EPRI *Steam Generator Integrity Assessment Guidelines* [2], provides the tools for compliance with program elements contained in NEI 97-06, *Steam Generator Program Guidelines* [1]. This document contains requirements and guidance on test objectives, test conditions, post-test requirements, procedural specifications, and degradation form screening criteria for proof and leak testing.

FOREWORD

This document was prepared by the Engineering and Regulatory Issues Resolution Group (E&R IRG) In Situ Guideline Ad Hoc Committee under the auspices of EPRI Steam Generator Management Project (SGMP). The Ad Hoc Committee members are listed below.

John Arhar	Pacific Gas and Electric
Helen Cothron	Tennessee Valley Authority
Richard Coe	Southern California Edison
Jeff LeClair	NMC/Xcel Energy
Joe Mathew	Omaha Public Power District
Dan Meatheany	Entergy
Mati Merilo	EPRI
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1
INTRODUCTION

1.1 Background

Degradation of steam generator tubing can lead to decreases in load bearing capacity and may compromise pressure boundary leak tightness. When such degradation is observed, evaluations are performed to ensure that required structural margins are maintained and that leak rates, should leakage occur, will remain within allowable limits. Structural integrity and leak rate evaluations may be based on one or more of the following elements:

- Non-destructive examination (NDE) results, such as eddy current, plus analytical/semi-empirical calculations of burst pressures and leak rates
- Laboratory burst and leak tests of pulled tubes with service-induced degradation
- In situ leak and/or proof testing of sections of tubing with eddy current indications of degradation.

Historically, some combination of the first two elements, inspection plus analysis and pulled tube examinations has formed the basis for structural integrity and leak rate evaluations. Testing of tubes removed from the steam generator provides an informative option with some uncertainty due to tube damage from the pulling operation. However, pulled tube examinations are expensive in terms of time, money and radiation exposure. Using eddy current inspection results to characterize the geometry of tube degradation coupled with analytical/semi-empirical calculations of burst pressures and leak rates is an economic, reliable option, but consideration of the uncertainties in sizing degraded regions can lead to overly conservative assessments of the severity of the detected degradation.

Since 1993, in situ pressure testing has been widely used in support of structural integrity and leak rate evaluations. In situ pressure testing refers to hydrostatic pressure tests performed on installed tubing in the field. The purpose of these tests is to demonstrate that the selected tubes satisfy specified structural and accident-induced leak rate performance criteria. For example, in situ testing has been used by many utilities to verify structural margins in instances where flaw NDE parameters have approached or exceeded minimum structural integrity threshold values (reduced for uncertainty). In situ pressure testing may be required to support the condition monitoring and operational assessment requirements of NEI 97-06, *Steam Generator Program Guidelines* [1].

The benefits of direct evaluation of the strength and leak rate properties of degraded sections of tubing can be realized with in situ testing. In situ testing allows for the real time measurement of structural and leakage margin without the inherent cost, schedule and potential uncertainties associated with pulling tubes for laboratory testing. For example, there has been documented evidence that the tube pulling operation can further degrade the flaw of interest (particularly if the flaw is circumferential in orientation) thereby introducing suspect leak and burst information. Additionally, pulled tube activities and subsequent laboratory time typically do not provide real time information to the user. As such, in situ testing has become a key element in the condition monitoring and operational assessment process.

The scope of this guideline includes tooling qualification, testing procedures, and information regarding the documentation and analysis of test results. This document also provides detailed protocols for the selection of tubes with various forms of degradation for in situ testing. Finally, the in situ testing guidelines, presented herein, are intended to complement the EPRI guidelines for laboratory burst and leak rate testing of steam generator tubing [3]. As such, the field test data may be used to support existing and future burst and leakage correlations.

1.2 Purpose

This document provides guidance and requirements for: (1) the conduct of in situ pressurization tests (2) the selection of steam generator tubes for structural integrity verification (3) the selection of tubes for in situ leak testing when leakage is present or has the potential to develop during normal operating or accident conditions and (4) engineering assessment of in situ results including necessary adjustments to relate room temperature test data with operating and accident conditions.

The information from in situ pressure testing is intended to support condition monitoring and operational assessments as required by NEI 97-06 and described in the EPRI *Steam Generator Integrity Assessment Guidelines* [2]. The guidance provided in this document is experienced-based, in that the protocol and desired output are achievable with available technology.

Utilities may deviate from specific requirements of this document by providing a documented technical justification in accordance with NEI 97-06 [1] for each deviation.

2
PROOF AND LEAK TEST OBJECTIVES

NEI 97-06, *Steam Generator Program Guidelines* [1], requires that the utility assess tube integrity after each steam generator inspection. The purpose of the assessment is to ensure that the performance criteria for structural and leakage integrity have been met for the previous operating period (e.g., condition monitoring) and will continue to be met for the next operating period (e.g., operational assessment). Meeting the structural limit criteria generally involves demonstrating that the burst pressure for the degraded tube meets a specified value containing a defined safety margin. Satisfying leakage criteria requires demonstrating that the total leakage from all tubes with flaws meets the licensing basis limits for accident leakage. The pressure and leak test objectives in Section 2.1 form the bases for the guidance contained in this document for the selection of tubes for in situ testing. Threshold NDE parameters are calculated to bound estimates of NDE uncertainties

2.1 Required Test Objectives

- Demonstrate structural integrity at end-of-cycle (EOC) satisfies the structural performance criteria in NEI 97-06 (e.g., no burst at 3NODP) in support of the condition monitoring assessment.
- Demonstrate acceptable leakage integrity at EOC as required by the accident induced leakage performance criteria of NEI 97-06, and in accordance with all applicable design bases assumptions, and site dose assessments.

2.2 Optional Test Objectives

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3 COMPLIANCE RESPONSIBILITIES

3.1 Introduction

The objective of this section is to identify organizational responsibilities for assuring that in situ testing activities achieve their full potential to enhance steam generator reliability.

Each utility shall assume responsibility for all those planned and systematic actions, such as in situ testing, necessary to provide adequate confidence that a structure, system, or component will perform satisfactorily in service. Planning and execution of these steam generator program elements, wholly or in part, may be delegated to others, such as contractors or consultants, but the ultimate responsibility rests with the utility. The authority and duties of persons and organizations planning and performing in situ testing shall be clearly established and delineated in writing.

3.2 Management Responsibilities

It is important that all levels of utility management understand the objectives and value of in situ testing as a direct means of demonstrating compliance with the structural and leakage integrity performance criteria contained in NEI 97-06. As such, this guideline provides the methodology for the selection of tubes to be tested, the conduct of testing and the documentation and interpretation of the test results. A standardized approach is designed to provide the following outcome:

- Assure accurate assessment of steam generator tube integrity
- Maximize the availability of the unit by verifying appropriate operating intervals
- Provide a direct means of demonstrating regulatory compliance
- Provide basis for immediate availability of the unit

3.2.1 Specific Management Responsibilities

Nuclear station management is responsible for providing sufficient resources and attention to steam generator in situ pressure testing. Specific management responsibilities shall include the following:

- Establish a strong statement of policy that includes full support of the implementation of this guideline.
- Develop a knowledgeable steam generator engineering organization with sufficient responsibility, authority and resources to implement this guideline.
- Support degradation assessment and outage planning which may include sufficient time and resources for the conduct of in situ testing.
- Provide independent and knowledgeable auditing organizations to periodically verify compliance with procedural implementation and application of test results.

3.3 Engineering Responsibilities

The responsibilities of the steam generator engineering organization include the planning, directing, and evaluation of in situ testing. Responsibilities shall include, but are not limited to, the following:

- Implement the EPRI Steam Generator In Situ Pressure Test Guidelines
- Generate a technical justification for any deviation to this guideline in accordance with NEI 97-06.
- Establish plant-specific threshold values for screening indications for in situ testing addressing plant specific integrity limits. Refer to the EPRI *Steam Generator Integrity Assessment Guidelines [2] and Flaw Handbook* [4] for guidance in developing threshold values. Voltage threshold values for screening flaws for leakage are provided in Section 4.5.
- Verify tooling used to conduct the testing is qualified for the stated test objectives (Section 9).
- Use a utility approved procedure for the conduct of in situ testing (Section 5.0).
- Document the selection or exclusion of tubes for testing.
- Provide appropriate oversight of the testing organization.
- Verify test results and identify any requirements for additional tests.
- Report any failures as required by NEI 97-06.
- Assess test results for condition monitoring and operational assessment.
- Ensure data is included in the EPRI Steam Generator Degradation Database (Section 7.0).
- Report to EPRI E&R IRG within 90 days when in situ tests result in leakage or burst.

3.4 NDE Considerations

Supplemental NDE considerations may be useful in supporting engineering evaluations of test results. These include:

- Consider conducting supplemental diagnostic NDE, as necessary, to characterize the critical flaw parameters. For example, ECT Rotating Pancake and/or Plus Point Probe may be considered to further characterize the flaw, including the peak and average depth of penetration, peak voltage, total length and width, through-wall length (if applicable), and effective length above the threshold length recommended for testing.
- Consider using other NDE techniques (such as ultrasonics, liquid penetrant) to further characterize the flaw profile particularly the through-wall length/area.
- Consider NDE data evaluation by sizing analysts in addition to the production analysts. The use of sizing analysts will provide added assurance that the NDE uncertainty numbers applied to the screening criteria are not encroached upon.
- Consider post testing NDE, including visual inspections, to evaluate changes in flaw characteristics

4
SCREENING PARAMETERS/TUBE SELECTION

4.1 Purpose

The purpose of the in situ test screening is to identify indications requiring testing to assess the capability of the steam generator tubing to meet structural and leakage performance criteria.

The term "quantified sizing" used in this section means that technique and analyst variability uncertainties are defined and the correlation satisfies statistical requirements specified in the *EPRI Steam Generator Integrity Assessment Guidelines* [2].

Section 4 provides screening criteria for in situ leak testing and proof testing under several different scenarios:

- Screening criteria for proof testing when sizing capabilities are fully quantified
- A ranking methodology for proof testing indications when sizing capabilities are not fully quantified. The basis for this methodology is included in Appendix C.
- Screening criteria for leak testing. This screen has steps that are applicable to techniques with and without quantified sizing techniques. Appendix B provides the basis for development of voltage screening threshold values.
- An alternative selection criteria for proof testing when sizing capabilities are fully quantified using a statistical approach (Appendix A).
- Screening methodology for mixed mode flaws.

Figures 4.1 and 4.2 are flow charts depicting Section 4 screening.

Appendix D identifies indications and situations that are exempt from in situ testing (e.g., location of the flaw in surrounding support structures, physical limitations of the in situ test equipment due to the location of the flaw).

4.2 Nomenclature

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4.3 General Requirements

In addition to the above tube selection guidance, the following general guidance applies to all types of indications:

- Technical specifications or licensing requirements supersede the requirements in this document for selecting tubes for in situ testing.
- All tubes with visible leakage as identified during the outage or during a secondary side leak test that are not associated with leak-limiting repairs or are not exempt by Appendix D shall be in situ tested unless a tube pull is planned. Tubes that leak at low pressures are likely to leak significantly more when exposed to the higher pressures associated with main steam line break pressures as a result of the increased crack opening area and potential failure of ligaments of non-corroded material.
- All tubes that require proof testing shall also be leak tested.
- All axial indications that require leak testing shall also be proof tested, except where Appendix D proof test exemptions are defined.
- Tube selection is based on consideration of the NDE inspection results in terms of indicated depth, length and/or voltage response.
- New degradation that does not fall within the guidance of Appendix D shall be in situ tested. New degradation is degradation never seen in the U.S. industry.
- Exemptions from testing shall be documented. Indications that are exempt from testing do not require further screening. In cases where the indication has burst and/or leakage potential but the results from an in situ test would be meaningless, satisfaction of performance criteria may be demonstrated by analytical methods or by tube pull. Indications should be reviewed against Appendix D guidance to determine if they are exempt from in situ testing.

4.4 Guidance on Tube Selection for Proof Testing

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4.4.1 Guidance on Tube Selection When Sizing Capabilities are Quantified

The selection process in this section can be utilized if NDE sizing capabilities are fully quantified.

The data set used to develop the NDE uncertainties shall be representative of field indications for the degradation mechanism and location in the SG.

Where NDE uncertainties are required, the total NDE uncertainty shall be used. This may be obtained by combining technique and analyst uncertainties or from correlations developed from testing of field analysts (e.g., site specific performance demonstration), which combines both technique and analyst variability uncertainties.

NDE measurements of the as-found indications are compared against plant-specific threshold values.

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4.4.2 Guidance on Tube Selection for When Sizing Capabilities are not Quantfied

The selection process in this section shall be utilized when NDE sizing capabilities are not fully quantified.

Appendix C provides the basis for a tube selection screening protocol for proof testing that is applicable for indications that do not have quantified NDE measurement uncertainties. The process begins with a quick screening and ends with a calculated relative ranking.

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4.4.3 Alternative Screening Methodology for Proof Testing

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4.5 Leak test screening criteria for techniques with and without quantified sizing techniques

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Table 4-1
Degradation Specific Voltage Values

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4.6 Mixed Mode Defects – Guidelines for Selecting Flaws for Proof and Leak Testing

A mixed mode flaw for this section is defined as an axial indication and a circumferential indication located in general proximity to each other (e.g., at the same TSP intersection). This section does not apply to other forms of interacting indications.

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4.7 Test Results

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Figure 4-1
Insitu Proof Test Flowchart for Axial, Circumferential, and Volumetric Flaws

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Figure 4-2
Insitu Leak Test Flowchart for Axial, Circumferential, and Volumetric Flaws

5
TEST PROCEDURE

5.1 Procedural Requirements

In situ testing shall be conducted in accordance with a utility approved procedure. The procedure shall follow the technical and qualification requirements expressed in Section 9. Since the test results are used to support tube integrity assessments, the test apparatus, instrumentation and procedures shall comply with all the requirements of 10CFR50 Appendix B. The criteria for the selection or omission of candidate tubes shall be documented. The minimum reporting requirements shall include the information identified in Sections 8.0.

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5.2 Post-Test Actions

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6 IN SITU TEST CONDITIONS

6.1 Introduction

This section includes guidance and requirements on test pressures and test pressure adjustments.

6.2 Test Pressures

The purpose of this section is to provide definitions for recommended and/or required test conditions, and hold-points for the conduct of in situ proof and leak tests. The utility shall document all required test conditions in the test record.

6.2.1 Normal Operating Differential Pressure (NODP)

This test pressure is intended to quantify leakage from the indication for normal operation during the previous cycle. The normal operating differential pressure is defined in the *Steam Generator Integrity Assessment Guidelines* [2].

6.2.2 Intermediate Leak Test Pressure (ITP)

If a leak is suspected, or occurs during performance of the test, an intermediate test pressure is intended to provide an additional leak rate point prior to the faulted condition test pressure. This information may be helpful in case of a failure. Select a pressure approximately half way between NODP and the estimated maximum achievable pressure up to the faulted accident condition test pressure.

6.2.3 Postulated Accident Conditions Test Pressure

An evaluation of plant conditions in the accident analyses shall be performed to identify the largest primary-to-secondary pressure differential. Additional conditions identified in the design and licensing basis shall be evaluated to determine if the associated loads contribute significantly to burst.

6.2.4 Intermediate Proof Test Pressure

Pressures with the minimum two (2) minute hold times at approximately every 500 psig or less, above the postulated accident conditions test pressure, should be considered, as structural capability can only be related to the highest held test pressure.

6.2.5 Proof Test Pressure

The proof test is defined as the pressure test demonstrating compliance with the structural performance criteria of NEI 97-06 [1].

6.2.6 Elevated Test Pressure

If it is desired to show that additional margin exists in the condition monitoring assessment test pressures may be elevated beyond those specified in Section 6.2.5 up to the maximum qualified pressure of the in situ system.

6.3 Test Pressure Adjustments

In situ pressure testing at room temperature conditions may not adequately simulate steam generator conditions during a postulated faulted event. Therefore, correction of pressures identified in Section 6.2 is necessary. The following test correction information is provided to support most applications of in situ testing.

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7 INDUSTRY DATABASE

Data obtained from in situ testing shall be entered into the EPRI Steam Generator Degradation Database (SGDD) within six months of the test. The database is on the EPRI web site at http://www.epri.com/sgdd. It is important that in situ data submittals be complete, correct and timely, as supporting information can result in more robust screening criteria. Improved screening criteria may assist utilities in the selecting of tubes to be tested to support structural and leakage performance criteria. Before this industry information can be used, an evaluation shall validate that the information contained in the database is applicable to the specific plant (e.g., degradation type, NDE response, tube geometry, deposits, etc.).

8 DOCUMENTATION AND REPORTING

In addition to utility specific technical specification reporting requirements, NEI 97-06 [1] contains additional reporting requirements if the condition of the steam generator tubes does not meet the specified performance criteria. Consequently, verified evidence of a tube(s) failing to meet the test objectives supporting the structural and leakage performance criteria shall be documented and reported to the NRC as required.

In situ pressure test data shall be included in the EPRI Steam Generator Degradation Database as described in Section 7. In situ screening criteria developed in accordance with Section 4 shall be documented.

If in situ test results in leakage or burst, test results shall be reported to the EPRI E&R IRG. This will result in a review of the databases used as bases for voltage screening values.

The application of the review process for screening indications shall be documented to provide evidence of the review.

A summary of the plant's test objectives and selection bases used in performing in situ testing shall be documented.

Qualification of the in situ pressure test equipment shall be documented.

9
EQUIPMENT SPECIFICATION REQUIREMENTS AND TOOL QUALIFICATION

9.1 Equipment Specification Requirements

In situ tooling systems can pressurize either the full length of the steam generator tube or some smaller length containing the degraded region. In either case, system performance shall be evaluated. System performance is influenced by the tooling capabilities, test objectives, conditions in the field environment and procedural adherence.

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9.2 Tool Qualification

This section provides guidance for the qualification of the in situ pressurization test apparatus whose function is to provide information relative to the structural integrity and leakage properties of degraded sections of steam generator tubing. It is recognized that different tooling may be used for leak integrity verification versus structural integrity testing.

The fundamental goal for the qualification of in situ pressurization tooling is to provide assurance that such tooling will generate leak rate and burst pressure data comparable to conventional laboratory systems used for leak rate and burst testing of degraded sections of steam generator tubing. The utility shall review and approve the documentation of the evaluation of the accuracy, capabilities and limitations of the in situ tooling.

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9.3 Additional Considerations

The tooling application procedure should consider duty cycles of testing equipment to limit the potential for a tooling malfunction in the steam generator.

In situ tooling seal performance should be evaluated, both with respect to maximum pressure limitations and likely seal leak rates as a function of pressure. Low levels of seal leakage are of interest especially if substantial numbers of tubes exhibit leakage. It is important to determine if leakage observed during in situ testing is actually related to tubing degradation or is simply a reflection of seal leakage. Qualification testing of non-degraded sections of tubing is useful in this regard since the only leakage possible is system leakage.

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Some additional considerations include: ease of use, reasonable setup and testing times, applicability to the locations of degradation of interest, radiation exposure involved in use, retrieval of all tooling materials, and low risk of damage to adjacent tubes should expected or unexpected tube bursts occur.

10
IN SITU PRESSURE TESTING AND LEAK RATE ADJUSTMENTS

10.1 Introduction

In situ pressure tests are typically conducted at room temperature. Therefore, adjustments are required to simulate both normal and accident conditions. Consequently, an engineering assessment shall be performed and maintained, or cited by reference, as part of the test record that demonstrates that the test is capable of producing the stress state at the flawed section of tubing which is equivalent to, or a conservative bound, of the actual stress state during normal operation and postulated accident conditions, multiplied by the appropriate factor of safety. The purpose of this chapter is to provide information regarding the assessments required to simulate the effects of induced axial loads during accident events, the impact of temperature on material properties and the differences in thermal hydraulic conditions for leak rates at accident conditions (phase change and flashing) versus test conditions.

10.2 Induced Axial Loads

In situ proof and leak rate tests for circumferentially oriented flaws shall consider the presence of axial loads during faulted MSLB event scenarios. These axial loads may result from either locked tubes in support plates for RSG designs, or from adverse tube-to-shell thermal differences in an OTSG. Locked tube adjustment factors to be applied to in situ test pressures are tooling and generator design specific and shall be coordinated with information from the original NSSS supplier and the in situ testing vendor. When evaluating the locked tube corrections, the tool design and operational characteristics, as well as the steam generator design and geometry can affect the correction to be applied.

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10.3 Temperature Adjustment

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Table 10-1
Material Property Corrections for Testing at Room Temperature to MSLB Conditions

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10.4 Adjustments of In situ Measured Leak Rates

In situ leak testing is normally performed at room temperature (~70°F) and the results are applied to one or more accident condition pressure differentials. Therefore, in situ leak rates must be corrected to accident conditions for comparison to the specified limits. The calculated accident induced leak rate should be compared to the performance criteria of NEI 97-06 [1].

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10.5 Basis for the Leakage Rate Adjustments

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10.5.1 Axial Cracks

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10.5.2 Circumferential Crack

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10.5.3 Flow rate

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10.5.4 Scaling Analysis

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10.6 Example Calculation

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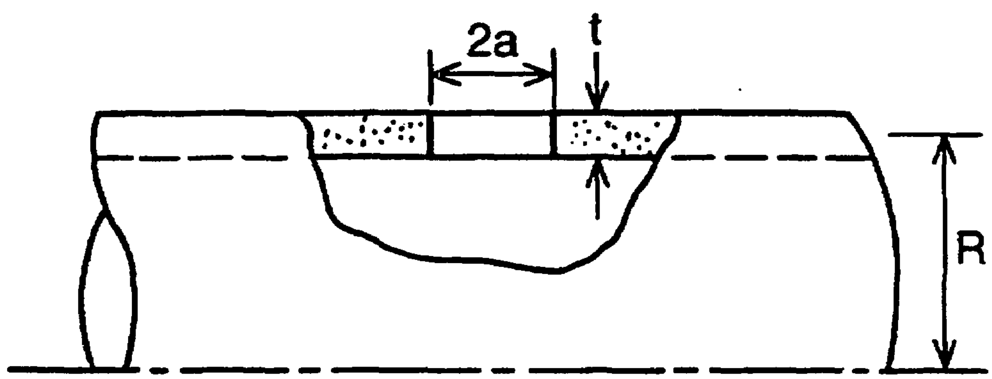

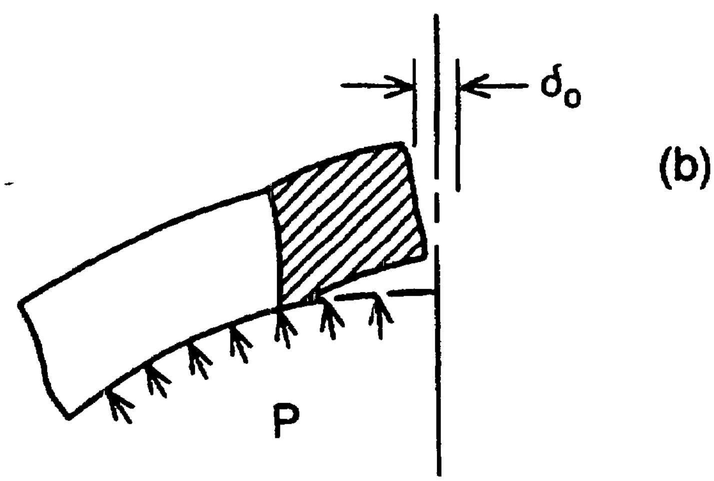

Figure 10-1
Pipe Axial Crack Geometry

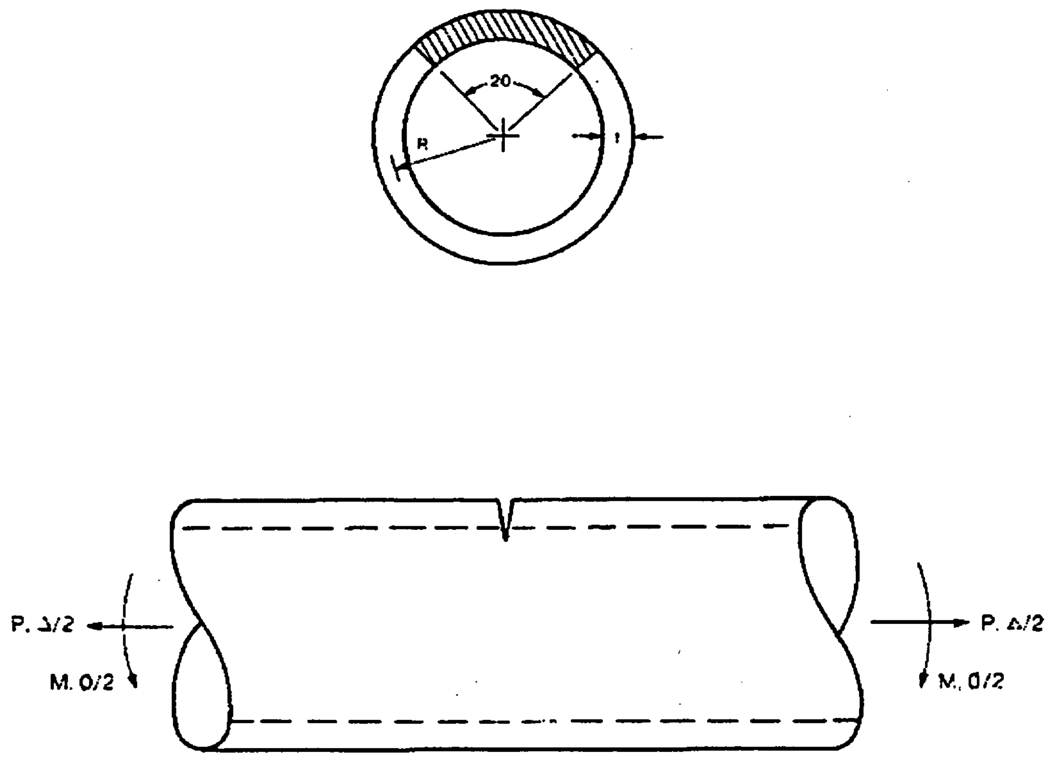

Figure 10-2
Pipe Circumferential Crack Geometry

11
REQUIREMENTS

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A

APPENDIX A – STATISTICAL APPROACH TO IN SITU TEST SELECTION

A.1 Introduction

The information contained in this appendix offers a more automated candidate selection process as opposed to the sequential process defined in Section 4. The approach described is based on defining the structural and leakage capacity of detected flaws in terms of NDE measurements, such that, by considering the appropriate uncertainties, the likelihood of meeting the NEI 97-06 [1] performance criteria is computed using confidence levels in accordance with the Steam Generator Integrity Assessment Guidelines [2].

As indicated in the EPRI *Steam Generator Integrity Assessment Guideline* [2], an evaluation strategy can be employed that permits candidate selection using various means of combining the uncertainties associated with determining structural and leakage capacity of a flawed steam generator tube. The scope of this appendix is to provide an example for this process.

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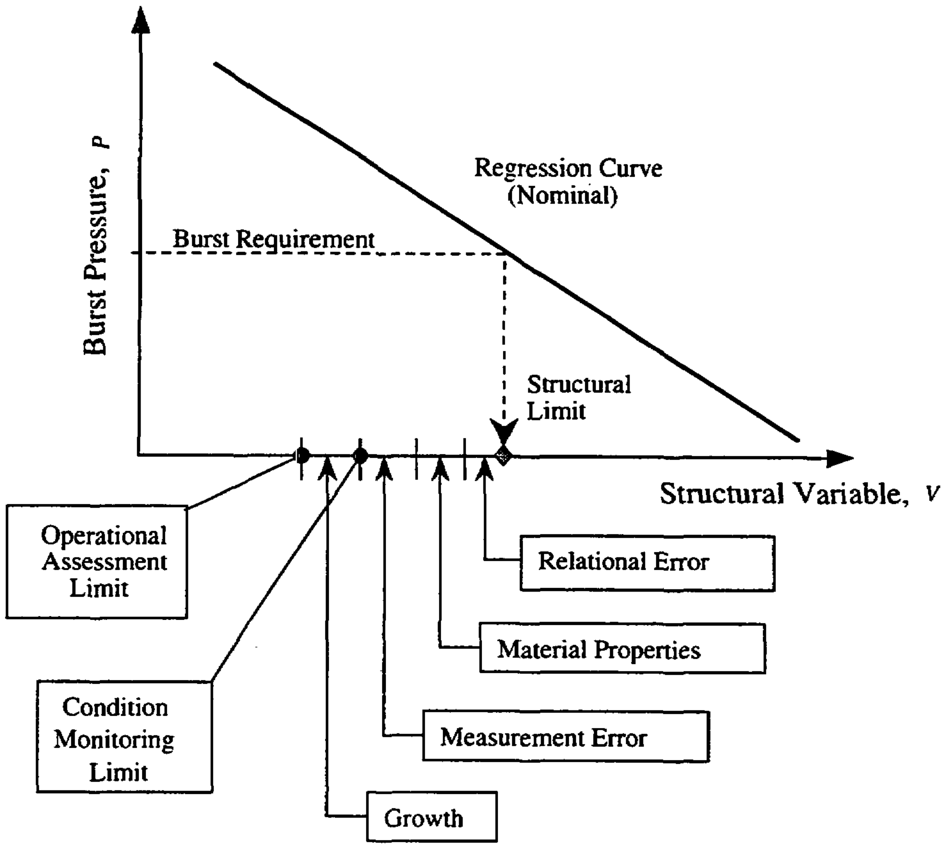

Figure A-1
Integrity Assessment Elements

A.2 Tube Selection for Proof Testing

Whereas the sequential selection approach outlined in Section 4.0 often relies on the development of bounding evaluation parameters, the Monte Carlo analysis approach to in situ candidate selection consists of simply generating a distribution of the burst pressures for the indicated flaw(s) based on drawing random values from the appropriate flaw component variables (e.g., material properties, NDE uncertainties) and calculating structural performance using valid models for computing burst strength.

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A.3 Tube Selection for Leakage Testing

A similar Monte Carlo analysis approach can be developed for determining candidate selection for verification of accident leakage integrity. Simulation models can be developed to estimate leak rate and probability of leak based on material property variability and sizing uncertainty. Since for any flaw a range of possible flaw or crack shapes exist, some of which may penetrate through wall and others which may not, a probability of leak (POL) needs to be assigned/computed for each indication.

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A.4 In Situ Candidate Selection

As indicated, the output of a Monte Carlo analysis is typically the predicted burst pressure or accident leak rate at a 90/50 probability and confidence. The predicted value is then compared to the performance criteria. If the predicted value does not meet the performance criteria, in situ testing is required.

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Table A-1
TW Axial Cracks Analysis Input Data—Length, Normalized Burst Relation & Strength Uncertainty Information

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Table A-2
Monte Carlo Analysis of Throughwall Cracks in SG Tubes – Sample Results
First Thirteen Simulations, Indicated Length = 0.500"

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Figure A-3
Condition Monitoring Throughwall Crack Burst Acceptance Limits

B
TECHNICAL BASIS FOR VOLTAGE AS SCREENING PARAMETER

B.1.0 Introduction

The primary objective of this appendix is to define a methodology for utilizing voltage as a screening parameter to select indications for in situ leak testing. A secondary objective is to define and support a lower bound voltage value for use as a screening parameter for pressure testing. For leak testing, the voltages are to be developed by applying the methods of this report for specific degradation mechanisms, location in the SG and SG design features such as the type of tube to tubesheet expansion (e.g., hardroll, explosive, hydraulic)

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B.2.0 Summary of Voltage Screening Values

The voltage screening parameters developed in this report for V_{THR-L} and V_{CRIT} are summarized in Table B-1. Results are included for axial and circumferential PWSCC and ODSCC crack indications as well as volumetric indications for pitting, wear and cold leg thinning degradation mechanisms.

Table B-1
Summary of Voltage Threshold Parameters for Leak Testing

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B.3.0 Methods for Developing Voltage Screening Values

B.3.1 Approach

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B.3.2 Voltage Screening Parameters from Prior In Situ Test and/or Destructive Exam Results

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B.3.3 Maximum Depth versus Voltage Correlation

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B.3.4 Lower Bound Voltages for Screening Indications for Pressure Testing

For pressure testing, the objective is to define a very conservative or lower bound voltage that essentially precludes the potential for a crack indication to burst at less than the burst margin requirements (i.e., $3\Delta P_{NO}$ for freespan indications).

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B.3.5 Probe and Voltage Normalization Requirements

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B.4.0 Voltage Parameters for Axial PWSCC Indications

B.4.1 Database

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B.4.2 Maximum Depth to +Point Voltage Correlation and Parameters

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B.4.3 Voltage Screening Parameters from Prior In Situ Test Results

B.4.3.1 Axial PWSCC in Hardroll Expansion Transitions

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B.4.3.2 Axial PWSCC in Explosive Expansion Transitions

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B.4.3.3 Axial PWSCC at Dented TSP and Eggcrate Intersections

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B.4.3.4 Axial PWSCC in U-Bends

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B.4.4 Summary

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Table B-2
Axial PWSCC in Hardroll Expansion Transitions: +Point Threshold Voltage Evaluation DE Data from Tube Exam Reports, NDE from EPRI SGDD Database and Westinghouse In Situ Test Records

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Table B-3
Explosive Expansion Axial PWSCC: +Point Threshold Voltage Evaluation Data from EPRI SGDD Database, 300 kHz, Volts Cal 20V for 100% EDM Axial Slot

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Table B-4
Axial PWSCC at Dented TSP and Eggerate Intersections: +Point Threshold Voltage Evaluation Data from EPRI SCDD Database and Reference 19, 300 kHz, Volts Cal 20V for 100% EDM Axial Slot

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Table B-5
U-Bend Axial PWSCC: +Point Threshold Voltage Evaluation – Data from EPRI SGDD Database, 300 kHz, Volts Cal 20V for 100% EDM Axial Slot

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Figure B-1
Axial PWSCC: Maximum Depth Versus Maximum +Point Volts

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Figure B-2
Axial PWSCC: Destructive Exam Max. Depth as Funtion of Max +Point Volts

B.5.0 Voltage Parameters for Axial ODSCC Indications

B.5.1 Database

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B.5.2 Maximum Depth to +Point Voltage Correlation and Parameters

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B.5.3 Voltage Screening Parameters from Prior In Situ Test Results

B.5.3.1 Axial ODSCC at Eggcrate Intersections

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B.5.3.2 Freespan Axial ODSCC in Westinghouse SGs

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B.5.3.3 Freespan Axial ODSCC in CE SGs

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B.5.3.4 Freespan Axial ODSCC in OTSGs

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B.5.3.5 Axial ODSCC in Dings

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B.5.3.6 OTSG SG Freespan and Tubesheet Volumetric OD Indications (Probable OD IGA)

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B.5.3.7 Axial ODSCC in Sludge Pile

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B.5.3.8 Axial ODSCC in Hardroll and Explosive Expansion Transitions

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B.5.3.9 Axial ODSCC in U-Bends

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B.5.3.10. Axial ODSCC at OTSG Tube Supports

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B.5.4 Summary

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Table B-6
Eggcrate Axial ODSCC CE SG's: +Point Threshold Voltage Evaluation – Data from EPRI SGDD Database and Supplemental ANO-2 Analyses, Volts Cal 20V for 100% EDM Axial Slot

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Table B-7
Freespan Axial ODSCC in Westinghouse SGs: +Point Threshold Voltage Evaluation – Data from EPRI SGDD Database and Reference 11, 300 kHz, Volts Cal 20V for 100% EDM Axial Slot

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Table B-8
Freespan Axial ODSCC in CE SGs: +Point Threshold Voltage Evaluation
(Data from EPRI SGDD Database and Pulled Tube Data from Westinghouse Files)

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Table B-9
Freespan Axial ODSCC OTSG SGs: +Point Threshold Voltage Evaluation
(In Situ and NDE Data from Framatome in Reference 15 and Pulled Tube Data from Reference 16).

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Table B-10
Ding Axial ODSCC: +Point Voltage Evaluation
(DE Data from Westinghouse Report SG-99-03-005; Voltages from Westinghouse Analyses OTSG Data (5/8" OD) from Reference 15)

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Table B-11
OTSG SG Freespan and Tubesheet Volumetric OD Indications (Probable OD IGA): +Point Threshold Voltage Evaluation
(In Situ and NDE Data from Framatome In Reference 15)

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Table B-12
Sludge Pile Axial ODSCC W and CE SGs: +Point Threshold Voltage Evaluation
(Data from EPRI SGDD Database and Westinghouse Files, 300 kHz, Volts Cal 20V for 100% EDM Axial Slot)

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Table B-13
Expansion Transition and U-bend Axial ODSCC: +Point Threshold Voltage
(Data from EPRI SGDD Database, 300 kHz, Volts Cal 20V for 100% EDM Axial Slot)

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Table B-14
OTSG Axial OD Indications at Tube Supports: +Point Threshold Voltage Evaluation
(In Situ and NDE Data from Framatome in Reference 15)

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Figure B-3
Axial ODSCC All Data

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Figure B-4
Axial ODSCC CE Data

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Figure B-5
Westinghouse Axial ODSCC Data

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Figure B-6
W SG Axial ODSCC

B.6.0 Voltage Parameters for Circumferential PWSCC Indications

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B.6.2 Maximum Depth to +Point Voltage Correlation and Parameters

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B.6.3 Voltage Screening Parameters from Prior In Situ Test Results

B.6.3.1 Circumferential PWSCC in Explosive Expansions

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B.6.3.2 Circumferential PWSCC in Hardroll Expansions

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B.6.3.3 Circumferential PWSCC in U-Bends

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B.6.4 Summary

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Table B-15
Explosive Expansion Circumferential PWSCC: +Point Threshold Voltage Evaluation
(Data from EPRI SGDD Database and Reference 10, 300 kHz, Volts Cal 20V for 100% EDM Axial Slot)

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Table B-16
U-Bend Circumferential PWSCC Westinghouse SGs: +Point Threshold Voltage Evaluation
(Data from EPRI SGDD Database, 300 kHz, Volts Cal 20V for 100% EDM Axial Slot)

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B.7.0 Voltage Parameters for Circumferential ODSCC Indications

B.7.1 Database

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B.7.2 Maximum Depth to +Point Voltage Correlation and Parameters

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B.7.3 Voltage Screening Parameters from Prior In Situ Test Results

B.7.3.1 Circumferential ODSCC in Hardroll Expansions

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B.7.3.2 Circumferential ODSCC in Explosive Expansions

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B.7.3.3 Circumferential ODSCC in U-Bends

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B.7.4 Summary

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Table B-17
Hardroll Expansion Circumferential ODSCC: +Point Threshold Voltage Evaluation
(Data from EPRI TR-107197-P2, Table G-11 and EPRI SGDD Database)

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Table B-18
Explosive Expansion Circumferential ODSCC: +Point Threshold Voltage Evaluation
(Data from EPRI SGDD Database and Reference 10, Volts Cal 20V for 100% EDM Axial Slot)

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Figure B-7
Circ. Dent & Explosive Exp. ODSCC

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Figure B-8
Circ. Dent & Explosive Exp. ODSCC: Destructive Exam

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Figure B-9
Circ. Hardroll ODSCC

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Figure B-10
Circ. Hardroll ODSCC: Pulled Tube Destructive Exam

B.8.0 Volumetric Indications

B.8.1 Approach

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B.8.2 Pitting

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B.8.3 Cold Leg Thinning

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B.8.4 Wear at TSP Intersections and AVB/Straps

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B.8.5 Summary

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Table B-19
Pitting: Bobbin Coil Voltage Threshold Evaluation
(DE Data from EPRI ETSS 96005.2, Rev. 5; Bobbin Voltages from Westinghouse Analyses)

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Table B-20
Bobbin Coil Cold Leg Thinning: 7/8" Tube Diameter, 0.050" Wall
(Westinghouse DE and NDE Data from Reference 17; Bobbin Voltages with Sludge in TSP Crevices)

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Table B-21
Bobbin Coil Wear at AVB/Straps and Tube Supports
(DE Data from EPRI ETSS 96004.1, Rev. 7; Differential Bobbin Voltages from Westinghouse Analyses)

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Table B-22
Bobbin Coil Wear at AVB/Straps and Tube Supports
(DE Data from EPRI ETSS 96004.2, Rev. 7; Absolute Bobbin Voltages from Westinghouse Analyses)

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Figure B-11
Pitting

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Figure B-12
Cold Leg Thinning

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Figure B-13
Wear at Tube Supports and AVB/Straps

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Figure B-14
Wear at Tube Supports and AVB/Straps

B.9.0 Maximum Depth and +Point Voltage Data

Table B-23
Axial PWSCC Database for Maximum Depth and +Point Volts

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Table B-24
Axial ODSCC Database for Maximum Depth and +Point Volts

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Table B-25
Circumferential ODSCC +Point Maximum Volts and Destructive Exam Data

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B.10.0 Voltage Ratios Between Coils and Tube Sizes

B.10.1 Objectives

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B.10.2 Ratio of +Point to 115 PC Voltages for Various Tube Sizes

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B.10.3 Ratios of 115 PC and +Point Voltages Between Westinghouse and CE SG Sizes

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B.10.4 Ratios of 115 PC and +Point Voltages Between Westinghouse SG Sizes

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B.10.5 Voltage Dependence on Throughwall Notch Length and Width

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B.10.6 Voltage Ratios for OTSG Volumetric Indications

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Table B-26
Ratio of +Point to 115 Pancake Coil Voltages for Various Tube Sizes

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Table B-27
Ratio of +Point to 115 Pancake Voltages as Functions of Length and Depth

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Table B-28
Ratios of 115 PC and +Point Voltages Between Westinghouse and CE SG Tube Sizes

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Table B-29
Ratio of 115 PC and +Point Voltages Between Westinghouse SG 7/8" and 3/4" Tube Sizes

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Table B-30
115 PC and +Point Voltage Dependence on Notch Width
(7/8" Diameter Tube, Notch 100% TW)

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Table B-31
OTSG 080 PC, 115 PC and +Point Voltage Dependence on Depth
(5/8" Diameter Tube, ASME Cal Std Holes)

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C
TECHNICAL BASIS FOR IN SITU PRESSURE TEST SCREENING PARAMETERS WHEN NDE SIZING IS NOT QUANTIFIED

C.1.0 Introduction

This appendix was prepared to address three issues related to the selection of tubes for in situ pressure testing when no adequately quantified correlation exists between eddy current parameters and the actual size of the flaw. The three issues are ranking of indications for in situ pressure testing, determination of the number of ranked indications that could require testing, and expansion of the sample size when one or more tubes fail the in situ pressure test. The goal is to identify all degradation capable of challenging structural integrity, and that any challenges to integrity are adequately evaluated. In situ proof testing is a tool used to supplement the NDE evaluation of the tubes.

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C.2.0 General Methods for Ranking and Selection of Indications for In Situ Pressure Testing

C.2.1 Issues to be Addressed

The following three issues are to be addressed to support selection of indications for in situ pressure testing.

1. Ranking of indications for in situ pressure testing where NDE uncertainties are not adequately quantified or the correlation coefficient does not establish a high degree of statistical confidence that a correlation exists between the measured size and the actual size of the flaw.

    - An adequately quantified correlation for NDE uncertainties requires both technique and analyst variability uncertainties to be included in the NDE uncertainties. An adequate correlation can be obtained by combining separately determined technique and analyst variability uncertainties or by testing of NDE analysts, which then includes both uncertainties. A statistically acceptable correlation must satisfy the correlation coefficient requirements of the EPRI SG Integrity Assessment Guidelines [2]. The ranking and selection requirements of this document apply when the requirements for an adequate correlation are not satisfied.

2. Determination of the number of ranked indications that could require testing.

3. Expansion of the in situ testing sample size for the case where one or more tubes fail the in situ test.

    - For the pressure testing requirements, failure is defined as the burst of the specimen prior to demonstrating the required burst pressure margin (i.e., $3\Delta P_{NO}$).

C.2.2 Ranking and Selection of Indications for Pressure Testing

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C.3.0 Initial Screening Parameters

C.3.1 Throughwall Length as Initial Screen for Pressure Testing

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C.3.2 Requirements for Calculating Throughwall Length Limits

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C.3.3 Lower Bound Voltage Screening Values for Pressure Testing

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C.4.0 Calculation of Ranking Factors

C.4.1 NDE Sizing Uncertainty Considerations

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C.4.2 Calculation of Relative Ranking Factors

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C.4.2.2 Circumferential Indications

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C.4.3 Validation of Methods

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C.4.4 Consistency in Analyses for Indications being Evaluated and Previously Tested Indications

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C.5.0 Selection of Indications for In Situ Testing With or Without Prior Test Results

C.5.1 Combined Ranking of New Indications and Prior Test Results

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C.5.2 Selection of Indications for Testing

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C.6.0 Expansion of In Situ Test Sample Size when One or More Indications Fail the Pressure Test

C.6.1 Applicability of In Situ Testing Expansion Guidelines

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C.6.2 Expansion Guidelines

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C.7.0 Methods Validation for Selection of Indications for In Situ Testing

C.7.1 Relative Burst Pressure Ranking Sensitivity to NDE Uncertainties

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C.7.2 Axial PWSCC NDE Sizing Evaluation for In Situ Testing

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C.7.3 Axial ODSCC NDE Sizing Evaluation for In Situ Testing

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C.7.4 Circumferential ODSCC NDE Sizing Evaluation for In Situ Testing

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C.7.4.1 Explosive Expansions

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C.7.4.2 Hardroll Expansions Data from EPRI Circumferential Crack Report

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Analysis assuming lowest burst pressure failed test (indication actually satisfied burst margins)

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Analysis assuming no indications failed testing using same data as above

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C.7.4.3 Analysis using data from ETSS 21410.1, Rev. 0.

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C.7.5 Conclusions

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Table C-1
Relative Burst Pressure Ranking Sensitivity to NDE Uncertainties

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Table C-2
Axial PWSCC at Dented Eggcrate Intersections: Methods Evaluation for In Situ Test Selection
Data from Reference 19. +Point Data for 600 mil coil, 0.4 ips, 300 kHz, Volts Cal 20V for 100% EDM Axial Slot

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Table C-3
Axial PWSCC at Dented Eggcrate Intersections: Methods Evaluation Assuming In Situ Test Failure
Data from Reference 19. +Point Data for 600 mil coil, 0.4 ips, 300 kHz, Volts Cal 20V for 100% EDM Axial Slot

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Table C-4
Axial ODSCC at Eggcrate Intersections: Methods Evaluation for In Situ Test Selection
Data from EPRI SGDD Database and Sizing Performed for ANO-2 1/99 and 11/99 Outages

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Table C-5
Explosive Expansion Circumferential ODSCC: Methods Evaluation for In Situ Test Selection
Data from EPRI Report TR-107197-P2 (Reference 10)

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Table C-6
Hardroll Expansion Circumferential ODSCC: Methods Evaluation for In Situ Testing with Burst Test Failure
Data from EPRI Report TR-107197-P2 (Reference 10)

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Table C-7
Hardroll Expansion Circumferential ODSCC: Methods Evaluation for In Situ Testing with No Burst Test Failure
Data from EPRI Report TR-107197-P2 (Reference 10)

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Table C-8
Hardroll Expansion Circumferential ODSCC: In Situ Evaluation Based on ETSS Data
Pulled Tube Data from EPRI ETSS 21410.1, Rev. 0

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C.8.0 Example Rankings Based Upon Available In Situ and Destructive Exam Test Results

This section provides example rankings of indications for prior in situ test results for hardroll circumferential ODSCC indications and axial ODSCC indications at eggcrate intersections.

C.8.1 Hardroll Circumferential ODSCC

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C.8.2 Axial ODSCC at Eggcrate Intersections

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Table C-9
Circumferential ODSCC Pulled Tube, Lab and In Situ Leak Test Data
Data from EPRI TR-107197-P2, Table G-11, EPRI SGDD Database and ETSS 21410.1, Rev. 0

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C.9.0 Technical Basis for Applying Maximum/Average Depth Ratio

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Figure C-1
Axial PWSCC Maximum to Average Depth Ratio – Burst Effective Data

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Figure C-2
Axial ODSCC Maximum to Average Depth Ratio – Burst Effective Average Depth

D
INDICATIONS EXEMPT FROM IN SITU TESTING

D.1 Introduction

The purpose of this appendix is to identify indications that are exempt from in situ testing because either the conduct of the test can not achieve the objectives, or integrity is inherently satisfied.

In order to comply with NEI 97-06 [1] requirements of assuring that the as-found tube condition complies with structural and leakage integrity requirements, this guideline requires that the user demonstrate that the test is capable of producing the stress state at the flawed section of tubing which is equivalent to, or a conservative bound, of the actual stress state during normal operation and postulated accident conditions multiplied by the appropriate factor of safety. In certain cases, this objective cannot be satisfied wholly through the conduct of in situ testing. For example:

- Indications in tubes with surrounding structures that would restrict leakage and/or burst during an in situ test render the results of an in situ test meaningless. Such defects include indications restricted from burst (IRB). In these cases, satisfaction of performance criteria may be demonstrated by analytical methods or by tube pull.
- Indications in locations that prohibit in situ testing due to physical limitations of the in situ test equipment. In these cases, satisfaction of performance criteria may be demonstrated by analytical methods or by tube pull.

There are also cases where proof testing is not required because structural integrity is inherently satisfied. For example:

- Surrounding structures (e.g., tubesheet) prevent tube burst during normal and accident conditions. Structural integrity is inherently satisfied, and in situ proof testing is not required. Leak testing may be necessary.
- Due to the nature of some damage mechanisms, the burst strength cannot be significantly degraded based on documented evidence. In situ proof testing is not required; however, leak testing may be necessary.

While not exempt from structural and leak rate testing, circumferentially cracked regions of a tube are inherently stronger than axial cracks (NUREG/ CR-6511). This is due to a combination of loading and geometry effects. The axial stress is only one-half of the hoop stress, the radial stiffness of the tube material is increased by the orientation of the crack, and the tube support structure results in the application of a load counter to the direction of deformation, i.e., bending of the tube is resisted.

D.2 Tubesheet Region

D.2.1 Proof Testing

For axial indications located within the tubesheet for tube/tubesheet expansions of any type (i.e., full depth or partial depth), burst cannot occur during normal operation and accident conditions due to the tubesheet constraint against radial deformation of the tube wall. As such, structural integrity is inherently provided, and proof testing is not required.

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D.2.2 Leak Testing

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D.3 Drilled Tubes Support Plate (TSP) Region

D.3.1 Proof Testing

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D.3.2 Leak Testing

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D.4 Leak Limiting Sleeves

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D.5 Tube Ends

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D.6 Tube Plugs

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D.7 Pitting

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