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Title Technical Requirements for W-44 F* Qualification

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Technical Manager Statement: Initials *EPB*

Reviewer is Independent.

Remarks:

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- (c) - The use of the information by a competitor would decrease his expenditures, in time or resources, in designing, producing or marketing a similar product.
- (d) - The information consists of test data or similar data concerning a process, method or component, the application of which results in a competitive advantage to BWNT.

Record of Revision

<u>Revision</u>	<u>Section</u>	<u>Description</u>
0	All	Original Issue

This document defines the technical requirements for F* criteria qualification in W-44 series steam generators.

1.0 BACKGROUND

The recirculating steam generators with alloy 600 tubing that have been mechanically roll expanded within the tubesheet have been prone to develop PWSCC in the roll transition regions. This qualification program, including testing and analysis, will be performed to show that some amount of tube degradation within the tubesheet is acceptable provided the structural integrity of the tube remains intact and that the plant technical specification leakage limits are met. The term F* defines a specific criteria pertaining to the length of undegraded hard roll contact necessary for degraded tubes to remain in service.

2.0 INTRODUCTION

In order to qualify F* for use in W-44 series RSGs, analysis and testing are required to define specific criteria which demonstrate adequate structural and leakage performance.

The F* length criteria assumes enough sound tube-to-tubesheet engagement exists such that below this distance a full circumferential tube sever can be tolerated.

This document provides the requirements necessary to conduct the qualifications for F*. Some of the performance characteristics from Table 1 have been obtained from the Indian Point-2 UFSAR.

3.0 APPLICABILITY

This document is applicable for W-44 Series RSGs with tubes which have been partially roll expanded into the tubesheet (up to [(c)] deep from the primary face).

4.0 REFERENCES

- 4.1 NRC Regulatory Guide 1.121, "Bases for Plugging Degraded PWR Steam Generator Tubes".
- 4.2 BWNS Document No. 08-1212587, "Equipment Specification for 7/8 RSG Tube Sleeve".
- 4.3 ASME Boiler and Pressure Vessel Code, Section III and Appendices, 1989 Edition.
- 4.4 ASME Boiler and Pressure Vessel Code, Section III and Appendices, 1965 Edition through Summer 1966 Addenda.

5.0 CUSTOMER REQUIREMENTS

The customer has imposed no requirements on the determination of these criteria.

6.0 TECHNICAL REQUIREMENTS

6.1 GENERAL

- 6.1.1 The criteria shall be applicable to all tube locations within the steam generator.
- 6.1.2 Testing and analysis must assume all cracks are 100% throughwall, 360° circumferential.
- 6.1.3 The F* criteria lengths shall be measured from the bottom of the uppermost roll transition.
- 6.1.4 The analysis and testing will verify that the criteria are conservative and meet NRC safety factors of 3 for normal operating conditions per Reference 4.1 and 1.43 for accident conditions per Reference 4.1 and 4.3, Appendix F. Reference 4.4 is the original Design Code for Indian Point-2.
- 6.1.5 The criteria will allow for eddy current uncertainty.
- 6.1.6 The criteria will meet the allowable leak rate limits as specified in plant technical specifications. The leakage limits shall not exceed [(d)] from any one RSG.
- 6.1.7 The qualification shall include, as a minimum, the design and operating conditions for Indian Point-2.

6.2 ANALYSIS

Calculations shall be performed which:

- (1) Determine the radial preload stress under the shop installed roll expansion conditions.
- (2) Determine the effects of plant operating and faulted conditions on radial preload stress. These calculations shall consider the effects of thermal expansion, internal pressure, tubesheet bow, seismic loading, and any potential additional loading effects, such as locked tubes at the tube support plates and flow loading. Provide locked tube loads to support testing.

The intended use for these analyses is to provide a ratio of the effects of operating and faulted conditions, listed in item 2 above, when compared against the shop installed condition. This ratio will be used to adjust the engagement length tested during mockup block qualification which will simulate the shop conditions.

Reference 4.1 provides the NRC criteria which must be considered in the analysis, as highlighted in Section 6.1.4. The conditions

and design constraints are summarized on Table 1 and Figure 1. The analysis T_{avg} shall be used for calculation purposes, as required. The values listed are a composite of the worst cases nominal and low T_{avg} operating conditions. The accident condition differential pressure loading was conservatively taken as 110% of the design pressure. Reference 4.2 may be used for general information not found in this document. Material properties are to be obtained from Reference 4.3.

NOTE 1: The tubesheet bore shall be utilized for calculating the maximum tube loads. Any seismic or faulted condition flow loading should be considered for additional tube loading effects.

NOTE 2: For the purposes of developing the loading on the tube in the event that the tube is locked into the TSP the following three cases shall be considered. The temperatures to use during this calculation are listed on Table 1.

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(d)

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[

(c)

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6.3 TESTING

A test plan must be prepared which addresses the following:

- (1) elastic springback/radial preload of the expanded tube
- (2) engagement length required to prevent tube slippage under operating and faulted loads
- (3) leakage rates at operation and faulted loads for the engagement lengths determined above to conservatively meet the limits of Section 6.1.6.

Acceptance requirements must also be established in the test plan to address each of these areas.

6.4 NON-DESTRUCTIVE EXAMINATION REQUIREMENTS

The ECT system, probe, calibration, and testing that will be utilized to perform the inspections associated with the F* criteria will be defined in the test plan. A commercially available eddy current system is to be used for all testing. The ECT system must determine the measurement accuracy associated with the following inspections:

- (1) identify the location of the highest pluggable indication within the roll expanded portion of the tube in the tubesheet.
- (2) identify the lower end of the upper roll transition.

6.5 TOOLING/MOCKUP FABRICATION

6.5.1 A roll expander shall be used which has a [(d)] total roll length with a minimum [(d)].

The minimum expansion range of the expander is to be [(d)]. The toe end of the roller shall be capable of being inserted up to [(d)] into the tube.

6.5.2 The roll expansion shall leave no unacceptable residue or contaminant in the tube. [(d)] is an acceptable lubricant. Felpro N-5000 shall not be used as a lubricant since its nickel content has an adverse effect on the ECT signal.

6.5.3 The roll expansion system must be capable of delivering [(d)] of torque. The amount of tube wall thinning for the qualification test specimens shall range from [(d)] to be representative of manufacturer installed hard rolls. The wall thinning values may be achieved by varying the tubesheet bore.

6.6 CORROSION

The effects of possible boric acid corrosion of the tubesheet when exposed to reactor coolant fluid are to be considered.

6.7 PROCESS VERIFICATION REQUIREMENTS

The qualifications for F* shall be documented in a topical report. This report shall include a "No Significant Hazards" review per 10 CFR 50.92.

Table 1
W-44 Performance Characteristics

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(c)

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Table 1
W-44 Performance Characteristics

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(c)

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Figure 1
W-44 General Arrangement

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(c)

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Figure .2
W-44 TSP Arrangement

(c)

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