UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

March 8, 2001

Mr. William T. Cottle
President and Chief Executive Officer
STP Nuclear Operating Company
South Texas Project Electric
Generating Station
P. O. Box 289
Wadsworth, TX 77483

SUBJECT: SOUTH TEXAS PROJECT (STP), UNIT 2 - ISSUANCE OF AMENDMENT REVISING THE TECHNICAL SPECIFICATIONS TO IMPLEMENT 3-VOLT ALTERNATE REPAIR CRITERIA FOR STEAM GENERATOR TUBE REPAIR (TAC NO. MA8271).

Dear Mr. Cottle:

The Nuclear Regulatory Commission (NRC) has issued the enclosed Amendment No. 114 to Facility Operating License No. NPF-80 for the STP Unit 2. The amendment consists of changes to the Technical Specifications (TSs) in response to your application dated February 21, 2000, as supplemented by letters dated January 24 and 30, and February 28, 2001.

The amendment revises the TSs approving the application of the 3-volt repair criteria to the methodology for repair of steam generator (SG) tubes. The new criteria apply for Unit 2 Cycle 9 only. The licensee intends to replace the Unit 2, Model E SGs during an outage currently scheduled to commence in the fall of 2002.

A copy of our related Safety Evaluation is enclosed. The Notice of Issuance will be included in the Commission's next biweekly *Federal Register* notice.

Sincerely,

Mohan C. Thadani

Mohan C. Thadani, Senior Project Manager, Section1
Project Directorate IV & Decommissioning
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-499

Enclosures: 1. Amendment No. 114 to NPF-80
2. Safety Evaluation

cc w/encls: See next page

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UNITED STATES
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STP NUCLEAR OPERATING COMPANY

DOCKET NO. 50-499

SOUTH TEXAS PROJECT, UNIT 2

AMENDMENT TO FACILITY OPERATING LICENSE

Amendment No. 114
License No. NPF-80

1. The Nuclear Regulatory Commission (the Commission) has found that:

   A. The application for amendment by STP Nuclear Operating Company* acting on behalf of itself and for Houston Lighting & Power Company (HL&P), the City Public Service Board of San Antonio (CPS), Central Power and Light Company (CPL), and the City of Austin, Texas (COA) (the licensees), dated February 21, 2000, as supplemented by letters dated January 24 and 30, and February 28, 2001, complies with the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act), and the Commission's rules and regulations set forth in 10 CFR Chapter I;

   B. The facility will operate in conformity with the application, as amended, the provisions of the Act, and the rules and regulations of the Commission;

   C. There is reasonable assurance (i) that the activities authorized by this amendment can be conducted without endangering the health and safety of the public, and (ii) that such activities will be conducted in compliance with the Commission's regulations;

   D. The issuance of this license amendment will not be inimical to the common defense and security or to the health and safety of the public; and

   E. The issuance of this amendment is in accordance with 10 CFR Part 51 of the Commission's regulations and all applicable requirements have been satisfied.

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*STP Nuclear Operating Company is authorized to act for Houston Lighting & Power Company (HL&P), the City Public Service Board of San Antonio, Central Power and Light Company, and the City of Austin, Texas, and has exclusive responsibility and control over the physical construction, operation, and maintenance of the facility.

2. Accordingly, the license is amended by changes to the Technical Specifications as indicated in the attachment to this license amendment and Paragraph 2.C.(2) of Facility Operating License No. NPF-80 is hereby amended to read as follows:

   2. Technical Specifications

      The Technical Specifications contained in Appendix A, as revised through Amendment No. 114 , and the Environmental Protection Plan contained in Appendix B, are hereby incorporated in the license. The licensee shall operate the facility in accordance with the Technical Specifications and the Environmental Protection Plan.

3. The license amendment is effective as of its date of issuance and shall be implemented within 30 days from the date of issuance.

FOR THE NUCLEAR REGULATORY COMMISSION

Robert A. Gramm

Robert A. Gramm, Chief, Section 1
Project Directorate IV & Decommissioning
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Attachment: Changes to the Technical Specifications

Date of Issuance: March 8, 2001

ATTACHMENT TO LICENSE AMENDMENT NO. 114

FACILITY OPERATING LICENSE NO. NPF-80

DOCKET NO. 50-499

Replace the following pages of the Appendix A Technical Specifications with the attached revised pages. The revised pages are identified by amendment number and contain marginal lines indicating the areas of change.

REMOVE	INSERT
3/4 4-12	3/4 4-12
3/4 4-13	3/4 4-13
3/4 4-13a	3/4 4-13a
3/4 4-14	3/4 4-14
3/4 4-15	3/4 4-15
3/4 4-16	3/4 4-16
3/4 4-16a	3/4 4-16a
3/4 4-16b	3/4 4-16b
	3/4 4-16c
3/4 4-18	3/4 4-18
3/4 4-18a	3/4 4-18a
B 3/4 4-3	B 3/4 4-3

*Overleaf pages provided to maintain document completeness. No changes on these pages.

REACTOR COOLANT SYSTEM

3/4.4.5 STEAM GENERATOR

LIMITING CONDITION FOR OPERATION

3.4.5 Each steam generator shall be OPERABLE.

APPLICABILITY: MODES 1, 2, 3, and 4.

ACTION:

With one or more steam generators inoperable, restore the inoperable generator(s) to OPERABLE status prior to increasing T_{avg} above 200°F.

SURVELLANCE REQUIREMENTS

4.4.5.0 Each steam generator shall be demonstrated OPERABLE by performance of the following augmented inservice inspection program and the requirements of Specification 4.0.5.

4.4.5.1 Steam Generator Sample Selection and Inspection - Each steam generator shall be determined OPERABLE during shutdown by selecting and inspecting at least the minimum number of steam generators specified in Table 4.4-1.

4.4.5.2 Steam Generator Tube Sample Selection and Inspection - The steam generator tube minimum sample size, inspection result classification, and the corresponding action required shall be as specified in Table 4.4-2 and Table 4.4-3. The inservice inspection of steam generator tubes shall be performed at the frequencies specified in Specification 4.4.5.3 and the inspected tubes shall be verified acceptable per the acceptance criteria of Specification 4.4.5.4. When applying the exceptions of 4.4.5.2.a through 4.4.5.2.c, previous defects or imperfections in the area repaired by sleeving are not considered an area requiring reinspection. The tubes selected for each inservice inspection shall include at least 3% of the total number of nonrepaired tubes in all steam generators and (for Model E steam generators only) 20% of the total number of repaired tubes in all steam generators; the tubes selected for these inspections shall be selected on a random basis except:

a. Where experience in similar plants with similar water chemistry indicates critical areas to be inspected, then at least 50% of the tubes inspected shall be from these critical areas;

b. The first sample of tubes selected for each inservice inspection (subsequent to the preservice inspection) of each steam generator shall include:

   1) All nonplugged tubes that previously had detectable wall penetrations (greater than 20%),

   2) Tubes in those areas where experience has indicated potential problems, and

SURVEILLANCE REQUIREMENTS (Continued)

3) A tube Inspection (pursuant to Specification 4.4.5.4a.9) shall be performed on each selected tube. If any selected tube does not permit the passage of the eddy current probe for a tube inspection, this shall be recorded and an adjacent tube shall be selected and subjected to a tube inspection.

4) For Model E steam generators only, indications left in service as a result of application of the tube support plate voltage-based repair criteria shall be inspected by bobbin coil probe during all future refueling outages.

c. The tubes selected as the second and third samples (if required by Table 4.4-2 or Table 4.4-3) during each inservice inspection may be subjected to a partial tube inspection provided:

1) The tubes selected for these samples include the tubes from those areas of the tube sheet array where tubes with imperfections were previously found, and

2) The inspections include those portions of the tubes where imperfections were previously found.

d. For Model E steam generators only, implementation of the steam generator tube/tube support plate repair criteria requires a 100-percent bobbin coil inspection for the flow distribution baffle plate intersections, for the hot-leg tube support plate intersections, and for the cold-leg tube support plate intersections down to the lowest cold-leg tube support plate with known outside diameter stress corrosion cracking (ODSCC) indications. The determination of the lowest cold-leg tube support plate intersections having ODSCC indications shall be based on the performance of at least a 20-percent random sampling of tubes inspected over their full length.

1) All intersections with mechanically induced dent signals greater than 5 volts identified by bobbin coil inspection shall be inspected by rotating pancake coil (or equivalent).

2) All intersections with large mixed residuals that could potentially mask flaw responses at or above the voltage repair limits shall be inspected by rotating pancake coil (or equivalent).

3) At the flow distribution baffle intersections, at the cold leg support plate intersections, and at the hot leg support plate intersections with support plates L through R (as identified in Figure 5.1 of WCAP-15163, Revision 1), tubes with degradation attributed to axially-oriented ODSCC within the bounds of the tube support plate with a bobbin voltage greater than the lower voltage repair limit (defined in 4.4.5.4.a.11) shall be inspected by rotating pancake coil (or equivalent).

SURVEILLANCE REQUIREMENTS (Continued)

4) At the hot leg support plate intersections with support plates C, F, and J (as identified in Figure 5.1 of WCAP-15163, Revision 1), all tubes with degradation attributed to axially-oriented ODSCC within the bounds of the tube support plate with a bobbin voltage greater than 3 volts shall be inspected by rotating pancake coil (or equivalent) eddy current probe. An additional 100 tube intersections with support plates C, F, and J with degradation attributed to axially-oriented ODSCC within the bounds of the tube support plate with a bobbin voltage less than 3 volts (100 total over all steam generators, not necessarily selected at random) shall be inspected by rotating pancake coil (or equivalent).

The results of each sample inspection shall be classified into one of the following three categories.

Category	Inspection Results
C-1	Less than 5% of the total tubes inspected are degraded tubes and none of the inspected tubes are defective.
C-2	One or more tubes, but not more than 1% of the total tubes inspected are defective, or between 5% and 10% of the total tubes inspected are degraded tubes.
C-3	More than 10% of the total tubes inspected are degraded tubes or more than 1% of the inspected tubes are defective.

Note: In all inspections, previously degraded tubes must exhibit significant (greater than 10%) further wall penetrations to be included in the above percentage calculations.

4.4.5.3 Inspection Frequencies - The above required inservice inspections of steam generator tubes shall be performed at the following frequencies:

a. The first inservice inspection following steam generator replacement shall be performed after 6 Effective Full Power Months but within 24 calendar months of initial criticality after the steam generator replacement. Subsequent inservice inspections shall be performed at intervals of not less than 12 nor more than 24 calendar months after the previous inspection. If two consecutive inspections, not including the preservice inspection, result in all inspection results falling into the C-1 category or if two consecutive inspections demonstrate that previously observed degradation has not continued and no additional degradation has occurred, the inspection interval may be extended to a maximum of once per 40 months;

   Note: Inservice inspection is not required during the steam generator replacement outage.

b. If the results of the inservice inspection of a steam generator conducted in accordance with Table 4.4-2 at 40-month intervals fall in Category C-3, the inspection frequency shall be increased to at least once per 20 months. The increase in inspection frequency shall apply until the subsequent inspections satisfy the criteria of Specification 4.4.5.3a.; the interval may then be extended to a maximum of once per 40 months; and

c. Additional, unscheduled inservice inspections shall be performed on each steam generator in accordance with the first sample inspection specified in Table 4.4-2 during the shutdown subsequent to any of the following conditions:

   1) Primary-to-secondary tube leaks (not including leaks originating from tube-to-tube sheet welds) in excess of the limits of Specification 3.4.6.2, or

   2) A seismic occurrence greater than the Operating Basis Earthquake, or

   3) A loss-of-coolant accident requiring actuation of the Engineered Safety Features, or

   4) A main steam line or feedwater line break.

4.4.5.4 Acceptance Criteria

a. As used in this specification:

1) Tubing or Tube means that portion of the tube or sleeve which forms the primary system to secondary system pressure boundary;

2) Imperfection means an exception to the dimensions, finish, or contour of a tube from that required by fabrication drawings or specifications. Eddy-current testing indications below 20% of the nominal tube wall thickness, if detectable, may be considered as imperfections;

3) Degradation means a service-induced cracking, wastage, wear, or general corrosion occurring on either inside or outside of a tube;

4) Degraded Tube means a tube containing imperfections greater than or equal to 20% of the nominal wall thickness caused by degradation;

5) % Degradation means the percentage of the tube wall thickness affected or removed by degradation;

6) Defect means an imperfection of such severity that it exceeds the plugging or repair limit. A tube containing a defect is defective;

7) Plugging Limit or Repair Limit means the imperfection depth at or beyond which the tube shall be removed from service by plugging or (for Model E steam generators only) repaired by sleeving in the affected area because it may become unserviceable prior to the next inspection. The plugging or repair limit imperfection depths are specified in percentage of the nominal wall thickness as follows:

a. original tube wall	40%
b. Westinghouse laser welded sleeve wall	40%

For Model E steam generators, this definition does not apply to tube support plate intersections for which the voltage-based repair criteria are being applied. Refer to 4.4.5.4.a.11 for the repair limit applicable to these intersections.

8) Unserviceable describes the condition of a tube if it leaks or contains a defect large enough to affect its structural integrity in the event of an Operating Basis Earthquake, a loss-of-coolant accident, or a steam line or feedwater line break as specified in Specification 4.4.5.3c., above;

9) Tube Inspection means an inspection of the steam generator tube from the point of entry (hot leg side) completely around the U-bend to the top support of the cold leg;

10) Preservice Inspection means an inspection of the full length of each tube in each steam generator performed by eddy current techniques prior to service to establish a baseline condition of the tubing. This inspection shall be performed prior to initial POWER OPERATION using the equipment and techniques expected to be used during subsequent inservice inspections.

11) For Model E steam generators only, Tube Support Plate Plugging Limit is used for the disposition of a mill annealed alloy 600 steam generator tube for continued service that is experiencing predominately axially oriented outside diameter stress corrosion cracking confined within the thickness of the tube support plates.

At the flow distribution baffle intersections, at the cold leg support plate intersections, and at the hot leg support plate intersections with support plates L through R (as identified in Figure 5.1 of WCAP-15163, Revision 1), the plugging (repair) limit is based on maintaining steam generator tube serviceability as described in a), b), c) and d) below:

a) Steam generator tubes, whose degradation is attributed to outside diameter stress corrosion cracking within the bounds of the tube support plate with bobbin voltage less than or equal to the lower voltage repair limit (Note 1), will be allowed to remain in service.

b) Steam generator tubes, whose degradation is attributed to outside diameter stress corrosion cracking within the bounds of the tube support plate with a bobbin voltage greater than the lower voltage repair limit (Note 1), will be repaired or plugged, except as noted in 4.4.5.4.a.11.c below.

c) Steam generator tubes, with indications of potential degradation attributed to outside diameter stress corrosion cracking within the bounds of the tube support plate with a bobbin voltage greater than the lower voltage repair limit (Note 1) but less than or equal to the upper repair voltage limit (Note 2), may remain in service if a rotating pancake coil inspection does not detect degradation. Steam generator tubes, with indications of outside diameter stress corrosion cracking degradation with bobbin voltage greater than the upper voltage repair limit (Note 2) will be plugged or repaired.

d) If an unscheduled mid-cycle inspection is performed, the mid-cycle repair limits apply instead of the limits identified in 4.4.5.4.a.11.a, 4.4.5.4.a.11.b, and 4.4.5.4.a.11.c. The mid-cycle repair limits will be determined from the equations for mid-cycle repair limits of NRC Generic Letter 95-05, Attachment 2, page 3 of 7. Implementation of these mid-cycle repair limits should follow the same approach as in TS 4.4.5.4.a.11.a, 4.4.5.4.a.11.b, and 4.4.5.4.a.11.c.

Note 1: The lower voltage repair limit is 1.0 volt for 3/4-inch diameter tubing.

Note 2: The upper voltage repair limit (V_{URL}) is calculated for each inspection according to the methodology in Generic Letter 95-05 as supplemented. V_{URL} may differ at the TSPs and flow distribution baffle. Voltage growth rate shall be the larger of the average growth rates experienced in the two prior cycles, but not less than 30% per effective full power year.

For Unit 2 Cycle 9 only, at the hot leg support plate intersections with support plates C, F, and J (as identified in Figure 5.1 of WCAP-15163, Revision 1), the plugging (repair) limit is based on maintaining steam generator tube serviceability as described in e), f), and g) below:

e) Steam generator tubes, whose degradation is attributed to axially oriented outside diameter stress corrosion cracking within the bounds of the tube support plate with a bobbin voltage less than or equal to 3.0 volts may remain in service.

f) Steam generator tubes, whose degradation is attributed to axially oriented outside diameter stress corrosion cracking within the bounds of the tube support plate with a bobbin voltage greater than 3.0 volts shall be plugged or repaired regardless of whether or not a rotating pancake coil inspection detects degradation.

g) If one or more indications in the tube support plate intersections are confirmed by non-destructive examination to extend beyond the edge of the tube support plate, the 3-volt alternate repair criteria shall not be used in any steam generator. Exceptions to this requirement may be allowed for those indications that are determined by the NRC staff to be physically insignificant for the purposes of safety and risk assessment. Approval for the use of the 3-volt alternate repair criteria may be granted by the staff in writing on a one-time basis, following the staff review and consideration of the factors related to the crack extensions that are found.

12) Tube Repair refers to a process that reestablishes tube serviceability for Model E steam generators only. Acceptable tube repair will be performed in accordance with the methods described in Westinghouse Reports WCAP-13698, Revision 2, "Laser Welded Sleeves for 3/4 Inch Diameter Tube Feedring-Type and Westinghouse Preheater Steam Generators," April 1995 and WCAP-14653, "Specific Application of Laser Welded Sleeves for South Texas Project Power Plant Steam Generators," June 1996, including post-weld stress relief;

Tube repair includes the removal of plugs that were previously installed as a corrective or preventive measure. A tube inspection per 4.4.5.4.a.9 is required prior to returning previously plugged tubes to service.

SURVEILLANCE REQUIREMENTS (Continued)

b. The steam generator shall be determined OPERABLE after completing the corresponding actions [plug or (for Model E steam generators only) repair all tubes exceeding the plugging or repair limit and all tubes containing through-wall cracks] required by Table 4.4-2 and Table 4.4-3.

4.4.5.5 Reports

a. Within 15 days following the completion of each inservice inspection of steam generator tubes, the number of tubes plugged or repaired in each steam generator shall be reported to the Commission in a Special Report pursuant to Specification 6.9.2;

b. The complete results of the steam generator tube inservice inspection shall be submitted to the Commission in a Special Report pursuant to Specification 6.9.2 within 12 months following the completion of the inspection. This Special Report shall include:

 1) Number and extent of tubes inspected,

 2) Location and percent of wall-thickness penetration for each indication of an imperfection, and

 3) Identification of tubes plugged or repaired.

c. Results of steam generator tube inspections which fall into Category C-3 shall be reported in a Special Report to the Commission pursuant to Specification 6.9.2 within 30 days and prior to resumption of plant operation. This report shall provide a description of investigations conducted to determine cause of the tube degradation and corrective measures taken to prevent recurrence.

d. For Model E steam generators, implementation of the voltage-based repair criteria to tube support plate intersections, notify the Staff prior to returning the steam generators to service should any of the following conditions arise:

 1) If estimated leakage based on the projected end-of-cycle (or if not practical, using the actual measured end-of-cycle) voltage distribution exceeds the leak limit (determined from the licensing basis dose calculation for the postulated main steam line break) for the next operating cycle. The calculation(s) shall be done using:

  a) The methodology of Generic Letter 95-05 for intersections at the flow distribution baffles, at the applicable cold leg support plates, and at the hot leg support plates L through R; and

SURVEILLANCE REQUIREMENTS (Continued)

b) The methodology of Generic Letter 95-05 modified for potential overpressurized tubes as described in WCAP-15163, Revision 1, for hot leg intersections at support plates C, F, and J.

2) If circumferential crack-like indications are detected at the tube support plate intersections.

3) If indications are identified that extend beyond the confines of the tube support plate.

4) If indications are identified at the tube support plate elevations that are attributable to primary water stress corrosion cracking.

5) If the calculated conditional burst probability based on the projected end-of-cycle (or if not practical, using the actual measured end-of-cycle) voltage distribution exceeds 1×10^{-2}, notify the NRC and provide an assessment of the safety significance of the occurrence. The calculation(s) shall be done using:

a) The methodology of Generic Letter 95-05 for intersections at the flow distribution baffles, at the applicable cold leg support plates, and at the hot leg support plates L through R; and

b) A total main steam line break tube burst probability of 1×10^{-5} for hot leg intersections at support plates C, F, and J.

6) If cracking is observed in the tube support plates.

7) If steam generator internals inspections are conducted and if indications detrimental to the integrity of the load path necessary to support the 3-volt alternate repair criteria are found, notify the NRC and provide an assessment of the safety significance of the occurrence.

e. For Model E steam generators, submit a report to the Staff that addresses "Information to be Provided Following Each Restart" per Generic Letter 95-05, 6.b, within 90 days following outage breaker closure.

Table 4.4-2

<u>STEAM GENERATOR TUBE INSPECTION</u>

1ST SAMPLE INSPECTION			2ND SAMPLE INSPECTION		3RD SAMPLE INSPECTION	
Sample Size	Result	Action Required	Result	Action Required	Result	Action Required
A minimum of S Tubes per S.G.	C-1	None	N.A.	N.A.	N.A.	N.A.
	C-2	Plug or repair defective tubes and inspect additional 2S tubes in this S.G.	C-1	None	N.A.	N.A.
			C-2	Plug or repair defective tubes and inspect additional 4S tubes in this S.G.	C-1	None
					C-2	Plug or repair defective tubes
					C-3	Perform action for C-3 result of first sample
			C-3	Perform action for C-3 result of first sample	N.A.	N.A.
	C-3	Inspect all tubes in this S.G., plug or repair defective tubes and inspect 2S tubes in each other S.G. Notify NRC pursuant to 10CFR50.72(b)(3)(ii)	All other S.G.s are C-1	None	N.A.	N.A.
			Some S.G.s C-2 but no additional S.G. are C-3	Perform action for C-2 result of second sample	N.A.	N.A.
			Additional S.G. is C-3	Inspect all tubes in each S.G. and plug or repair defective tubes. Notify NRC pursuant to 10CFR50.72(b)(3)(ii)	N.A.	N.A.

$S = 3 \frac{N}{n} \%$ where N is the number of steam generators in the unit, and n is the number of steam generators inspected during an inspection.

Table 4.4-3

MODEL E STEAM GENERATOR REPAIRED TUBE INSPECTION

1ST SAMPLE INSPECTION			2ND SAMPLE INSPECTION	
Sample Size	Result	Action Required	Result	Action Required
A minimum of 20% of repaired tubes [1]	C-1	None	N.A.	N.A.
	C-2	Plug defective repaired tubes and inspect 100% of the repaired tubes in this S.G.	C-1	None
			C-2	Plug defective repaired tubes
			C-3	Perform action for C-3 result of first sample
	C-3	Inspect all repaired tubes in this S.G., plug defective repaired tubes and inspect 20% of the repaired tubes in each other S.G.	All other S.G.s are C-1	None
			Some S.G.s C-2 but no additional S.G. are C-3	Perform action for C-2 result of first sample
		Notify NRC pursuant to 10CFR50.72(b)(3)(ii)	Additional S.G. is C-3	Inspect all repaired tubes in each S.G. and plug defective repaired tubes. Notify NRC pursuant to 10CFR50.72(b)(3)(ii)

[1] Each repair method is considered a separate population for determination of scope expansion.

STEAM GENERATORS (Continued)

plants have demonstrated the capability to reliably detect degradation that has penetrated 20% of the original tube wall thickness. Repaired tubes are also included in the inservice tube inspection program.

For Model E steam generators only, the voltage-based repair limits of SR 4.4.5 implement the guidance in GL 95-05 and are applicable only to Westinghouse-designed steam generators (SGs) with outside diameter stress corrosion cracking (ODSCC) located at the tube-to-tube support plate intersections. The criteria of GL 95-05 are also applicable to the Unit 2 flow distribution plate intersections. The voltage-based repair limits are not applicable to other forms of SG tube degradation nor are they applicable to ODSCC that occurs at other locations within the SG. Additionally, the repair criteria apply only to indications where the degradation mechanism is dominantly axial ODSCC with no significant cracks extending outside the thickness of the support plate. Refer to GL 95-05 for additional description of the degradation morphology.

Implementation of SR 4.4.5 for Model E steam generators requires a derivation of the voltage structural limit from the burst versus voltage empirical correlation and then the subsequent derivation of the voltage repair limit from the structural limit (which is then implemented by this surveillance).

The voltage structural limit is the voltage from the burst pressure/bobbin voltage correlation, at the 95-percent prediction interval curve reduced to account for the lower 95/95-percent tolerance bound for tubing material properties at 650°F (i.e., the 95-percent LTL curve). The voltage structural limit of the tube at flow distribution baffle intersections, (which have large tube to plate clearances) is based on a $3\Delta P_{NO}$ structural margin. For tubes at the cold leg tube support plate intersections and the hot leg intersections at plates L through R for which the small clearances provide constraint against tube burst during normal operation, the structural limit is based on a $1.43\Delta P_{SLB}$ structural margin. For the hot leg intersections at plates C, F, and J with the limited displacement of the lower tube support plates demonstrated by analyses in WCAP-15163, Rev. 1, Addendum 1, the constraint of the tube support plate reduces the burst probability of those tubes having axially oriented ODSCC indications that are confined within the tube support plate to negligible levels and the tube repair limit is not required to prevent tube burst. The need for tube repair is dictated by the need to satisfy allowable` steam line break leakage limits.

For those intersections where the possibility of tube burst must be considered (i.e., at the flow distribution baffle, at cold leg intersections, and at the hot leg intersections at plates L through R), the voltage structural limit must be adjusted downward to obtain the upper voltage repair limit to account for potential flaw growth during an operating interval and to account for NDE uncertainty. The upper voltage repair limit; V_{URL}, is determined from the structural voltage limit by applying the following equation:

$$V_{URL} = V_{SL} - V_{GR} - V_{NDE}$$

where V_{GR} represent the allowance for flaw growth between inspections and V_{NDE} represents the allowance for potential sources of error in the measurement of the bobbin coil voltage. Further discussion of the assumptions necessary to determine the voltage repair limit are discussed in GL 95-05.

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO AMENDMENT NO. 114 TO

FACILITY OPERATING LICENSE NO. NPF-80

STP NUCLEAR OPERATING COMPANY, ET AL.

SOUTH TEXAS PROJECT, UNIT 2

DOCKET NO. 50-499

1.0 INTRODUCTION

By a letter dated February 21, 2000 (reference 1) ; as supplemented by letters dated January 24 and 30, and February 28, 2001 (references 2, 3, and 7) ; South Texas Project Nuclear Operating Company (STPNOC or the licensee) requested revision to South Texas Project (STP) Unit 2 Technical Specifications (TSs) regarding alternate repair criteria (ARC) for hot leg-side steam generator (SG) tubes with respect to intersections at tube support plates (TSPs). The January 24 and 30, and February 28, 2001 letters, provided additional clarifying information that was within the scope of the original application and *Federal Register* notice and did not change the staff's initial proposed no significant hazards consideration determination.

The licensee proposed to amend its TSs to apply 3-volt ARC for evaluation of intersections of tube hot-legs to selected TSPs. As requested in January 24, 2001 letter, the 3-volt ARC will apply only to Model E SG tubes experiencing outer diameter stress corrosion cracking (ODSCC) at the intersections of tube hot-legs and TSPs C, F, and J (see Figure 1). The amended ARCs will be effective for Unit 2 Cycle 9 only. The licensee intends to replace the currently installed Model E SGs in the fall of 2002.

Using the conditions in the SGs for the postulated steam line break (SLB) as the design-basis accident, the licensee evaluated the thermal hydraulic conditions in the SGs to determine the hydraulic loads to TSPs; performed the TSP structural analysis to estimate the TSP deflections; and using the results of its analyses developed its basis for revisions to the TSs to permit application of 3-volt ARC to the intersections of tube hot-legs and TSPs C, F, and J, until the licensee replaces the currently installed Model E SGs in the fall of 2002.

2.0 EVALUATION

2.1 Background

General Design Criterion (GDC) 14 of Appendix A to Part 50 of Title 10 of *Code of Federal of Regulations* (10 CFR) requires that the reactor coolant pressure boundary be designed, fabricated, erected, and tested so as to have an extremely low probability of abnormal leakage, of rapidly propagating failure, and of gross rupture. To satisfy GDC 14, the acceptance criteria

(i.e., repair limits) for degraded SG tubes are specified in the plant TSs. The traditional strategy for achieving adequate structural and leakage integrity of the degraded tubes has been to establish a minimum wall thickness requirement in accordance with NRC Regulatory Guide (RG) 1.121, "Bases for Plugging Degraded PWR Steam Generator Tubes." The minimum wall thickness requirement was developed with the assumption of uniform thinning of the tube wall. This assumed degradation mechanism is inherently conservative for certain forms of tube degradation. Conservative repair limits may lead to removing degraded tubes from service that may otherwise have adequate structural and leakage integrity for further service.

In the early 1990's, to reduce unnecessary conservatism in the minimum wall thickness requirement for certain degradation, the industry proposed voltage-based repair criteria for predominately axial ODSCC confined within the thickness of the TSPs. On that basis, in 1993, the staff published several conclusions regarding voltage-based repair criteria in draft NUREG-1477, "Voltage-Based Interim Plugging Criteria for Steam Generator Tubes." On August 3, 1995, the staff issued Generic Letter (GL) 95-05, "Voltage-Based Repair Criteria For Westinghouse Steam Generator Tubes Affected By Outside Diameter Stress Corrosion Cracking," that took into consideration public comments, domestic operating experience under the voltage-based repair criteria, and additional data made available from European nuclear power plants.

The guidance of GL 95-05 does not set repair limits on tube wall thickness on predominantly axially oriented ODSCC indications; rather it sets voltage-based repair limits which are based on empirically derived correlations between a nondestructive inspection parameter, the bobbin coil voltage, and tube burst pressure and leak rate. A tube with an ODSCC indication having a bobbin voltage, which is lower than the repair limit, may remain in service. If the bobbin voltage exceeds the repair limit, the tube must be repaired. The repair limit for the 0.75-inch diameter tubing is 1 volt. The staff recognizes that although the total tube integrity margins may be reduced from minimum wall requirements based on RG 1.121 following application of the voltage-based repair criteria, the guidance in GL 95-05 ensures structural and leakage integrity continue to be maintained at acceptable levels consistent with the requirements of 10 CFR Part 50 and 10 CFR Part 100. Since the voltage-based repair criteria do not require minimum tube wall thickness, there is a possibility for tubes with through-wall cracks to remain in service. Considering the likelihood of such flaws, GL 95-05 provides provisions for augmented SG tube inspections and restrictive operational leakage limits.

GL 95-05 specifies, in part, that: (1) the repair criteria are only applicable to predominantly axially oriented ODSCC, having certain low bobbin voltages, which are located within the thickness of the TSP; (2) licensees perform an evaluation to confirm that the degraded SG tubes will retain adequate structural and leakage integrity from cycle to cycle; (3) licensees adhere to specific inspection criteria to ensure consistency in methods between inspections; (4) tubes must be periodically removed from the SGs, examined, and destructively tested to verify the morphology of the degradation and provide burst and leakage data for structural and leakage integrity evaluations; (5) the operational leakage limit in the plant TSs be reduced; (6) licensees implement an operational leakage monitoring program; and (7) specific reporting requirements be incorporated into the plant TSs.

In 1995, Commonwealth Edison submitted to the NRC a license amendment request to implement the use of a higher voltage repair limits than the repair limits under GL 95-05 for ODSCC indications constrained inside the thickness of a TSP at the Byron/Braidwood nuclear

stations. The GL 95-05 repair limit of 1 volt for the 0.75-inch diameter tubing was raised to 3 volts. The Commonwealth Edison proposed 3-volt ARC follow a similar GL 95-05 approach but with certain changes to GL 95-05 methodology that are suitable to the technical basis of the 3-volt ARC because certain TSPs are being locked by expansion joints. By a letter dated November 9, 1995, the NRC approved the implementation of the 3-volt ARC through operating cycles 6 and 8, for Braidwood Nuclear Power Station, Unit 1 and Byron Nuclear Power Station, Unit 1, respectively (reference 4). By a letter dated May 14, 1997, the NRC approved the 3-volt ARC for operating cycles 7 and 9 for Braidwood Unit 1 and Byron Unit 1, respectively (reference 5).

The technical basis of the 3-volt ARC proposed by STPNOC is similar to the 3-volt ARC implemented at the Byron/Braidwood stations. However, STPNOC will limit its 3-volt ARC to ODSCC indications detected at the intersections of TSP C, F, and J only. The existing 1-volt ARC at STP Unit 2 will cover the ODSCC indications detected at other applicable TSP intersections. The TSPs that are covered by the 1-volt ARC and 3-volt ARC will be specified in the revised plant TSs.

2.2 Thermal Hydraulic Evaluation

South Texas Project Unit 2 steam generators are of Westinghouse Model E2 design (Figure 1). Each steam generator contains 4,851 U-tubes of 0.75 inch outside diameter and o.043-inch wall thickness. Linear portion of the inverted-U-shaped steam generator tubes pass through TSPs at various levels to minimize lateral tube motion. During a SLB accident, pressure drop across the TSPs causes elastic displacement of TSPs. The magnitude of the deflections depends on the location, loading, and the normal support geometry of TSPs. The deflection would expose degraded tube spans which are otherwise circumferentially constrained by respective TSPs. The exposures of the degraded spans of tubes are a source of increase in tube burst probability and tube leakage. The NRC staff evaluated, as follows, the licensee's thermal hydraulic analysis to determine the loading on TSPs during an SLB accident.

The STP Unit 2 SG has a venturi flow restrictor in the main steam line nozzle at the top of the SG to limit the break flow rate during a SLB accident. There are several open volumetric regions in the flow paths below the nozzle with horizontal cross-sectional areas between 75 and 145 times the size of the restrictor flow area. The licensee states that these regions will tend to buffer pressure fluctuations that enter the SG from the SG exit venturi or from the steam line and they will result in reduced steam velocities near the top of the SG in comparison to the SG exit venturi velocity.

When the SG is operating at power, the water in most of the tube bundle region is a two-phase mixture of steam and water with increased quality in the higher regions of the tube bundle. Typically, subcooled water will be present in the preheater section of the bundle with slight subcooling in the lower regions of the bundle just above the tube sheet. The flow in the tube bundle will be upwards due to the density difference between the two-phase fluid in the heated tube bundle and the single phase fluid in the unheated downcomer. Almost all the liquid entrained in the flow leaving the tube bundle is separated by gravity in the steam separators and returned to the bottom of the tube bundle via the downcomer annulus. The ratio of the total flow in the bundle to the steam flow escaping the main steam nozzle is about 2.35 during full power operation. At full power, the largest pressure drop across a TSP is less than 1 psid.

When a large SLB occurs at full power, the SG exit flow increases by about a factor of 3 until the flow through the SG exit venturi chokes. The resulting depressurization at the top of the SG disrupts circulation flow and the downcomer flow reverses to help supply flow to the break. Consequently, when a large SLB occurs from full power operating conditions, there will be a moderate flow increase in the bundle that is directly attributable to the break. However, there is a secondary, more substantial, contribution to flow in the tube bundle caused by the swelling of the fluid in the tube bundle due to flashing as the SG pressure decreases. This swelling generates the peak loads on the TSPs during the early part of a SLB. Since the tube bundle region already contains substantial voids when the SG is operating, the surge associated with swelling in the tube bundle from a SLB from hot standby conditions is expected to result in the worst case TSP loads.

Starting at the hot leg-tube sheet and moving upward, the STP Unit 2 SG has 10 TSPs (Figure 1). The lowest TSP, "A", extends across the entire diameter of the tube bundle. On the hot leg side, the next three TSPs (C, F, and J) are half-diameter TSPs separated from the TSPs on the cold leg side by a vertical plate. The next six TSPs (L, M, N, P, Q, and R) are full diameter TSPs with TSP R located just below the U-bend region of the tube bundle. Moving upward, the vertical separator plate starts between TSP A and TSP C, and stops at TSP L.

During normal operation, hot water from the steam separators flows down the downcomer. Feedwater enters the SG on the cold leg side via a preheater region where it both receives heat from the cold leg side tubes and mixes with some of the downcomer water. Some of this water flows upward. The remainder flows horizontally beneath the vertical separation plate to enter the hot leg tube region. Thus, one may posit that flow direction below TSP C has both a horizontal and vertical component, while flows immediately above TSPs F and J are principally vertical. Following a SLB, if flow through TSP C is downward, then one may posit little variation in pressure along the surface of TSP C if much of the flow higher in the tube bundle is upward since the factors influencing a horizontal pressure variation from below TSP C will be diminished.

The NRC staff review focused on hydraulic loads that potentially affect movement of TSPs C, F, and J and the tubes penetrating those TSPs. The concern encompasses any potential TSP movement, tube movement, or component distortion, regardless of direction. In this sense, the licensee's restriction of the amendment request to TSPs C, F, and J is critical because hydraulic forces due to SG blowdown can be approximated by a one dimensional (vertical) analysis in this region of the SG. (This is not the case for the preheater region and perhaps TSPs A, L, and M, where multidimensional flows appear likely to occur. It would be difficult to justify application of a one dimensional analysis to such regions.)

Even in one dimensional space, there are severe analysis capability restrictions. We are not aware of the existence of qualified thermal-hydraulic codes to address all SG behavior under SLB conditions. Some analyses have been done using thermal-hydraulic codes designed for primary system analysis, but these have not been qualified for prediction of secondary side response to a SLB. The licensee approached these concerns in several ways:

1. It proposed added structural support by staking 16 SG tubes to TSPs C, F, and J to limit TSP movement. This additional structural support provides a substantial safety factor that reduces the need for precision in the thermal-hydraulic analysis.

2. It applied first-principles assumptions to calculate blowdown behavior to establish a large safety factor between predicted hydraulic loads and the loads necessary to cause concern.

3. It bounded blowdown behavior by assuming one case in which all fluid moved upward from the tube sheet through the TSPs to the outlet, one in which all fluid moved upward through the downcomer (downward in the TSPs), and one in which flow split equally between upward flow leaving the tube bundle and in the downcomer.

4. It assessed force propagation concerns by using a qualitative argument based on large volumes that attenuate forces originating outside the SG and by a limited oscillatory analysis to assess coupling between forces at the SG exit venturi and the TSPs.

The licensee's request is limited to one refueling cycle. Thus, the NRC staff review is limited to the STP Unit 2 plant for Operating Cycle 9. In addition, the NRC staff have carefully considered the licensee's analysis assumptions and its plans for plant-specific modifications to the SGs to provide appropriate safety margins.

2.2.1 Pressure Differential Across TSPs Due To Causes Originating Inside The SG During SG Blowdown

When a SLB occurs, the SG will begin to depressurize and hot water in the tube bundle will begin to flash. This results in a sudden swell that forces fluid in the tube bundle to expand through the TSPs. There are two exit paths from the tube bundle that the expanding fluid can take -- up through the U-bends and into the separators or down towards the tubesheet and up the downcomer annulus. Since the flow will escape in opposite directions, there will be a stagnation region in the tube bundle where the vertical flow is essentially zero. Fluid above this stagnation region will go up towards the U-bends and fluid below this region will go down towards the tubesheet and up through the downcomer.[1]

The load on a particular TSP will result from the accumulation of flow from the expansion of all the fluid between the stagnation region and that TSP. Therefore, an assumption that the stagnation region is too low will result in conservative loads on the upper TSPs and non-conservative loads for the lower TSPs. Conversely, an assumption that the stagnation region is too high will result in conservative loads on the lower TSPs and non-conservative loads on the upper TSPs.

The licensee used this concept to estimate TSP loading. First, it assumed the SG initially could be described by two homogeneous regions, an upper region containing saturated steam and a lower region containing saturated water. Then, the initial break flow rate was determined from the critical mass flux for saturated steam as a function of pressure as provided by the American Society of Mechanical Engineers (ASME) steam tables. For the first time step, the mass and energy in the upper region were reduced as a result of flow out the steam nozzle while the

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[1]Since the hot and cold leg sides of tube bundle are separated by a vertical baffle near the bottom of the SG, there may actually be two stagnation regions, one on the hot leg side and one on the cold leg side. TSPs C, F, and J, the regions of concern here, are on the hot leg side.

mass and energy of the lower region were unchanged as the boundary of this region was selected to contain the original mass. Thus, the lower region expands and the upper region contracts to maintain pressure equilibrium between the two regions while the total volume is constant. This causes vapor to be formed in the lower region since the specific volume increases but the total mass remains constant. Once the new volume of the lower region is determined, a new specific volume for the expanded fluid in that region can be calculated. As a result of the reduced pressure and the expansion of fluid in the lower region, the volume of the SG between the tubesheet and the top TSP will lose mass. Continuing this process throughout the blowdown, the rate of change of mass in the tube bundle from one time step to the next provides an estimate of the flow leaving the tube bundle during the time step. By making assumptions regarding the path that this flow must take as it flows out of the tube bundle region, the licensee estimated flow rate through each TSP and then calculated pressure difference across the TSPs. For example, by assuming that all the flow from expansion of the fluid in the tube bundle must flow upwards, the top TSP must pass all the flow while the bottom TSP will only pass the expanded flow from the region below it. Consequently, the load on the top TSP will be overestimated while the load on the bottom TSP may be underestimated. Conversely, if all of the flow were to be assumed to be downward, the bottom TSP loading would be maximized while the top TSP loading may be minimized.

Three separate flow distribution assumptions were employed to bound behavior:

1. It was assumed that no flow can escape up the downcomer and all flow must pass up through the tube bundle. This assumption provides conservative results for the upper TSPs as they experience the full expansion flow, some of which would normally escape up the downcomer.

2. It was assumed that half the flow escapes upwards through the tube bundle and half the flow escapes through the downcomer. Due to the higher resistance for the flow path through the downcomer, if the fluid conditions in each path are the same, then the tube bundle flow will be higher than the downcomer flow and the assumption of an equal flow split would be expected to be conservative for calculating the pressure drops for the lower tube support plates.

3. It was assumed that the full flow escapes through the downcomer in a manner opposite to that used for Case 1. The licensee believed this would be overly conservative for results for the lower TSPs because of the flow path resistances identified in Case 2.

The licensee summarized the calculated peak pressure drops for the hot leg TSPs as follows:

Plate	Up-Flow Only (psid)	Split Flow (psid)	RELAP5 Results (psid)
A	0.013	-5.068	-0.97
C	0.139	-2.346	-0.88
F	0.534	-1.376	-0.66
J	1.756	-0.983	-0.71
L	1.011	-0.056	0.68
M	1.254	0.003	0.63
N	1.893	0.094	0.95
P	2.653	0.314	1.31
Q	3.553	0.665	1.64
R	3.559	0.890	1.67

where the RELAP results are provided for comparison purposes.[2] Also note the licensee stated that the normal operating Δp across the TSPs is <1 psid.

Examination of the table shows the following:

1. For the upflow only case, the maximum Δp across plates C, F, and J is 1.76 psid at plate J. The maximum Δp across any TSP is 3.56 psid at plate R, the uppermost plate in the bundle.

2. For the assumption of a 50/50 split flow through the downcomer and through the bundle, the maximum Δp across any of the plates (except the Flow Distribution Baffle, Plate A) is –2.35 psid at plate C.

The licensee performed sensitivity analyses in which it concluded:

1. For an assumed TSP R Δp of 3.56 psid, taken individually across TSPs C, F, and J, the maximum TSP displacement would be 0.048 inches.

2. For a postulated Δp of 13.3 psid, which maintains the structural components within elastic limits, the maximum TSP displacement would be about 0.18 inches.

3. For an assumed TSP R Δp of 3.56 psid, taken additively across TSPs C, F, and J, the factor to reaching an elastic limit was 1.29. (The predicted limiting criterion was stress in the expanded tubes.)

4. The maximum calculated TSP displacement at the limiting load occurs at about 10 percent of tubes within 20 percent of the largest deflection of the hot leg intersections.

The NRC staff notes that the bounding analysis predicts a Δp of -2.346 psid for TSP C. Since, during normal operation, there is a positive Δp across this plate, the relative plate movement during the SLB would be the displacement during normal operation plus the SLB displacement (assuming the unexpanded tubes are not locked into the TSPs). In other words, if the normal Δp across TSP C was 1 psid, the effective Δp causing a displacement would be the sum of the two Δp's since they are in opposite directions, 3.346 psid. Similarly, where the SLB Δp is positive, the relative movement due to the accident would be represented by the difference. The licensee did not mention this effect.

2.2.2 Pressure Differential Across TSPs Due To Causes Originating Outside The SG During SG Blowdown

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[2]Although the RELAP5 analysis is far more detailed than the rudimentary analysis used to obtain the other tabulated results, there are unresolved issues regarding its applicability. These include aspects of the model that involve multidirectional flow, cross flow in tube bundles, and lack of comparisons between predictions and test data. Nonetheless, it is somewhat assuring that the RELAP5 predictions are between the bounds predicted by the rudimentary analysis predictions.

The licensee performed a limited assessment of potential SG and steam line pressure fluctuations by dividing conditions into three categories:

1. Initially, for a large SLB, pressure fluctuations in the steam line downstream of the SG exit venturi will not be able to propagate into the steam generator via the flow path. Consequently, the licensee concluded this aspect was not of concern.

2. If the SLB area is less than about 0.45 square feet or about 1/3 of the area of the SG exit venturi, the break flow will be less than that normally experienced during operation. The licensee concluded that this type of break was not of concern.

3. For a break area smaller than the nozzle area, but larger than identified in Item 2, the break flow could exceed the full power operating flow with an unchoked SG exit venturi. Under these conditions, pressure fluctuations in the steam line might propagate into the SG and affect the internals. The licensee performed a limited assessment of this effect.

The licensee first noted that the large volume of compressible steam at the top of the SG would act as an accumulator to help to isolate the lower internals from the effect of sudden pressure changes in the steam line. The licensee also noted that additional isolation for the tube bundle region is provided by resistance across the two levels of steam separators and the presence of large amounts of saturated liquid that can flash to maintain the pressure near saturation pressure. As a result, the licensee claimed that any sudden depressurization in the steam line would lead to a much slower depressurization of the SG and relatively small pressure gradients would be expected inside the tube bundle. The licensee further claimed that the pressure gradients that are established are primarily a result of "steady flow" rather than dynamic imbalance due to flow acceleration and the dominant loads on the TSPs result from the swell of fluid trapped by the TSPs as the SG begins to depressurize rather than from the propagation of sonic waves from the main steam nozzle.

To estimate the extent to which pressure fluctuations in the steam line could propagate into the tube bundle, the licensee conducted a two-phase thermal-hydraulic analysis for which a sinusoidal pressure oscillation was imposed at the steam line boundary. The SG was assumed to be at hot standby. The pressure response in the tube bundle region was determined as a function of the applied oscillatory pressure in the steam line. The analyses were run until steady state oscillating conditions were achieved. Several such analyses were conducted using several different frequencies for the pressure oscillations to determine the frequency transform for the pressure oscillations between the steam line and the tube bundle region. The licensee claimed that results from its calculation technique were compared to analytic solutions for wave propagation in piping systems with good agreement, but that assessment was not submitted for review.

Five runs were discussed with pressure oscillation frequencies between 10 and 50 Hertz. At low frequency, the calculated amplitude of the pressure oscillations at the tubesheet was about 7 percent of the amplitude of the applied pressure oscillations in the steam line whereas the amplitude of the pressure oscillations at the U-bends was about 2 percent of the applied amplitude. There appeared to be some frequency dependence for the response at low frequencies, particularly near the steam nozzle. The licensee stated that this may indicate an acoustic resonance effect at the top of the SG since the response was about 90 degrees out of phase with the applied pressure. However, the licensee stated that the response in the tube bundle remained low for all the analyzed frequencies and, for frequencies above 30 Hertz, the

calculated response in the tube bundle was claimed to be negligible. The licensee's results are summarized in the following table:

Frequency	Relative Response in Percent		
	Inside Nozzle	U-Bends	Tubesheet
10	7.2	1.9	6.7
20	4.2	4.9	8.0
30	16.9	0.8	1.1
40	5.5	0.1	0.1
50	3.0	0.05	0.05

The percentages are relatively low, but should be considered in conjunction with the driving functions -- the steam line loads. The licensee did not provide steam line load information. Also omitted from the licensee's submittal was discussion of lower frequency response, (which appears to have occurred during the Turkey Point SLB), potential shifting of choke locations between the steam line and the SG exit venturi, and loads generated by high flow rates through the SG exit venturi.[3]

2.2.3 Conclusions Regarding Thermal Hydraulic Evaluation

The licensee assessed TSP hydraulic forces during a SLB blowdown by separately examining (1) SG blowdown without oscillatory or shock wave phenomena and (2) the potential for oscillatory or shock wave phenomena.

With respect to analysis of hydraulic forces during a SLB, these are areas in which applicable experimental data are sparse and verified analysis techniques do not appear to exist. Consequently, one must rely in part upon reasonable judgment that considers the phenomena, the operating time, and the likelihood of encountering the conditions of concern. With respect to operating time, the licensee has requested applicability for one refueling cycle. With respect to the likelihood of encountering the conditions of concern, relatively large SLBs occurred twice in this country during startup testing in 1970 and in 1971 due to inadequately sized pipes associated with the SG safety valves. There has never been a large SLB at an operating nuclear power plant in this country although, of course, this does not mean a SLB could not occur.

The licensee's SLB bounding analysis for blowdown is based on a rudimentary representation of the SG design and is subject to numerous approximations. Consequently, this is not a precision analysis and its applicability is limited. However, the analysis appears reasonable when applied in a bounding manner by assuming all up-flow and then assuming a 50/50 split flow to estimate bounding forces on TSPs C, F, and J. The TSP displacements associated with these two bounds are then shown to be substantially removed from displacements of concern, an important consideration when judging the adequacy of the analysis. Consequently, we find

[3]It is well known that a cavitating venturi in a pipe can cause significant pipe vibration. In this case, the question would be whether such loads are transmitted into the SG shell and hence into SG internal components. These areas are not addressed by the SRXB review.

the bounding analysis to be sufficiently robust to be acceptable for STP Unit 2 for one fuel cycle.

The licensee essentially bases its conclusion that external loads will not propagate to the TSPs on the capability of choked flow at the nozzle to prevent downstream loads from propagating upstream and that any loads that do propagate upstream under non-choked conditions will be sufficiently attenuated in the steam and two-phase volumes between the nozzle and the TSPs. The licensee provided some limited analyses to substantiate this conclusion via qualitative justifications and an oscillatory analysis. The NRC staff does not consider these justifications and analyses to be sufficient for long-term resolution of these load issues. However, since the likelihood of a large SLB is small during the limited time of one operating cycle at STP Unit 2, the staff concludes that the licensee's substantiation that downstream loads will not dominate TSP response during a large SLB is sufficient.

The licensee's request applies to plant-specific conditions and a plant-specific SG design for a single fuel cycle. The NRC staff findings are not applicable to other nuclear power plants or to other operating conditions. Further, they are only applicable where there is a substantial safety factor between the predicted hydraulic TSP loads and the loads that are acceptable based upon the calculated capability of those TSPs.

2.2.4 TSP Displacement Analysis Review

The analytical justification for the 3-Volt ARC applicable to certain hot leg intersections of TSP is provided in the Westinghouse Topical report WCAP-15163; Revision 1 (in reference 1). An addendum to Reference 1 submitted by the licensee on January 30, 2001 (reference 3), provided additional information to address issues that arose during review of the proposed ARC. In addition, the licensee is proposing hydraulic expansion of 16 tubes in the hot leg at tube support plates C, F, and J to lock the TSP's in place (refer to Figure 1 for letter designations). The licensee contends that this provides added margins against TSP displacement and thus further reduces the probability of burst and leakage during bounding loading conditions.

As a precursor to performing a full bundle dynamic analysis to determine relative tube/TSP displacements for the bounding main stream line break (MSLB) loads, a preliminary analysis was performed using statically applied pressure loads. The preliminary analysis was performed to identify the number and location of expanded tubes within the lower region of the tube bundle hot leg for limiting TSP displacements under MSLB loads.

The analysis for the determination of TSP displacements involved the preparation of a finite element model that simulated the structural response of the tube bundle. The model included 180 degrees of the tube bundle, due to hot-to-cold leg asymmetry resulting from the presence of the preheater. The model included the channel head, shell, wrapper, partition plate, impingement plate in the preheater waterbox, all of the flow baffles and TSP, and the stayrods and spacers. The WECAN computer code, a general-purpose finite element code, was used to develop the model. The model was composed mainly of shell elements, with beam elements used to model the stayrods, spacer, and tubes. Calculations were performed to define applicable dynamic degrees of freedom (DOF) for each plate. Once the DOF was determined, a global substructure is generated for the overall tube bundle. The dynamic response of the plates is then calculated using the special purpose computer program "pltdym." Both the

WECAN and "pltdym" computer codes have been previously evaluated and approved by the staff for similar applications.

Once the dynamic response of the TSPs was determined, calculations were performed to assure the applicability of the elastic analysis approach in determining the resulting displacements. These calculations focused on showing that the stayrods/spacers remain elastic throughout the transient, significant yielding of the TSPs does not occur, and the welds joining the vertical bars and wedges (which provide vertical restraint for the plates) to the partition plate and wrapper remained intact.

The material properties for the tubesheet and TSPs were modified to account for the tube penetrations, flow holes, and various cutouts. The properties that were modified are Young's modulus, Poisson's ratio, and the material density. In the case of the TSP C, the density was additionally modified to account for the added mass of the secondary side fluid.

Because this is an elastic-static calculation, a reference load of 1 psi differential pressure was applied to the TSPs and the results scaled to higher loads as applicable. For the initial computer analysis to identify the number and location of the expanded tubes, only Plate C was active in the model while Plates F and J were active for the final computer analysis. Several load cases were evaluated for pressure drops in both the upward and downward directions. For the case of upward loads, the wedge supports at the plate/wrapper interface were active. However, for the downward loads the wedge supports were not active as the wedges do not provide any restraint to plate motion in the down direction. Relative to the interface between the plates and the stayrods and spacers, the plates were coupled to the stayrods through the spacers for upward loads. For loads in the downward direction, the plates were coupled to the spacers which transmitted the load to the tubesheet.

In determining the number and location of the expanded tubes, the objective was to show that for pressure loads significantly above the bounding pressure load of 3.56 psi differential pressure, the structural response would remain elastic, and that the peak plate displacements would not exceed 0.3 inch. When incorporating the restraining effect of the expanded tubes in the structural model, it became necessary to accurately represent the stiffness of the TSP expansion joint. The stiffness of the expansions was based on test data for prototypic expansions. The structural model considered the interaction effects, since applying load to Plates F and J also affects the response for Plate C, due to load transmittal through the expanded tubes. As the upper plates (above plate J) are loaded, there will also be an effect on the lower plates, however, the effect will not be as large, as the upper plates are coupled to the lower plates only at the stayrod locations and not at the expanded tube locations. The stayrod design cannot transmit tensile loads from a higher TSP to a lower TSP, but extension of the stayrods can relieve the constraint against upward deflection on the lower TSP's.

The validity of the elastic static analysis is contingent on the component structures remaining elastic under the applied load. The limiting components under the applied loads are the TSPs. Table 4.4 of reference 3, provides a summary of the maximum TSP stresses. These stresses represent the average stress across a plate ligament between holes. These stresses were calculated by applying concentration factors to the equivalent plate stresses obtained from the finite element model. The stress concentration factors are obtained from separate finite element model analyses of representative TSP sections.

The maximum plate stresses summarized in Table 4.4 of reference 3 are very localized in the plate, with the stresses in the majority of the plate well below the yield. These stresses also represent the bending stress at the surface of the plate, and do not indicate the development of a plastic hinge in any given ligament. The yield stress in the analysis is based on the minimum acceptable yield stress as defined in the material specification for the plates, scaled to high temperature conditions using the ASME Code temperature dependent strength properties.

Stresses in the stayrods and spacers are summarized in Table 4.5 of reference 3. Although the stresses in these components will increase when pressure loads are applied to the remaining plates, a significant margin exists relative to yield for the load conditions analyzed.

The staff notes that additional technical areas would need to be addressed with respect to the TSP displacements values and their application to the 3-Volt ARC for potential applications beyond the one cycle of operation. These areas include the methodology for computing the stress concentration factors related to the determination of the maximum tube support plate stresses and detailed assurance that component structures remain elastic under the applied loads.

2.2.4.1 Conclusions Regarding Support Plate Deflection Review

Based on its review as discussed above, the staff concludes that the TSP displacements at specified hot leg intersections remain less than 0.3 inch for the bounding differential pressure loads of 3.56 psi, thus limiting the probability of burst for the outer diameter cracks confined within the support plates to within acceptable limits.

2.3 Evaluation of the Licensee's 3-Volt Repair Criteria

2.3.1 Description of SGs

There are four Westinghouse model E2 SGs with a preheater region at STP Unit 2. Each SG has 4,851 tubes. All tubes are fabricated from mill-annealed Alloy 600 except for 15 tubes in SG 2D that are thermally-treated Alloy 600. Each tube has an outside diameter 0.75 inch and a thickness of 0.043 inch. The Unit 2 SGs have stainless steel drilled-hole TSPs which are 0.75-inch thick. The tubes pass through stainless steel tube support plates which provide lateral support to the tubes. Each TSP also contain circulation holes for water/steam to circulate in the tube bundle.

The designation for the TSPs are A, B, C, D, E, F, G, H, J, K, L, M, N, P, Q, and R (Figure 1). Plate A is referred to as the flow distribution baffle plate which is located about nine inches above the top of the tubesheet and directs the flow across the tubesheet and upward through a cutout in the plate on the hot-leg side. Plate R is the highest elevation plate, closest to the U-bend region of the tubes. Plates B, D, E, G, H and K are referred to as baffle plates which are half circular plates without flow circulation holes. The baffle plates are a part of the preheater and are on the cold-leg side of the SG. Plates C, F, and J are also half circular plates and are a part of the hot-leg side of the SG. TSPs C, F, and J are located on the opposite side of the preheater baffle plates, separated by a vertical partition plate. Plates L, M, N, P, Q and R are circular plates without a vertical partition plate.

The flow distribution baffle plates, preheater baffle plates, and TSPs are supported by a system of stayrods, welded wedges and backing bars. The TSPs are supported by 14 vertical

stayrods/spacers and additional 18 stayrods in the preheater region. The stayrods extend from plate A to plate R. The bottom of the stayrod is threaded to the top of the tubesheet and the top of the stayrod is fastened with a nut which is tack welded to Plate R. The spacers are tubing that sheathe the stayrod between each TSPs. In the preheater region, stayrods are segmented rods tack welded to the flow distribution baffle plate and run between the various baffle plates. Each segment threads into the lower end of the stayrod immediately above it. There are no spacers surround the preheater stayrods.

The periphery of each TSP is supported by pairs of upper and lower vertical bars that are welded to the various locations on the wrapper and the partition plate. Wedges are welded around the wrapper which limit the upper and lateral movement of the TSPs. The wrapper is attached to the SG shell by various vertical support blocks and anti-rotation support keys that are welded to either the shell or wrapper.

2.3.2 Proposed 3-volt ARC

The following criteria will be included in the plant TS as discussed in section 2.4.0 of this evaluation.

(1) The proposed 3-volt ARC will apply to predominately axial oriented ODSCC detected in the tube at the intersections of TSPs C, F, and J.

(2) The proposed 3-volt ARC will be applicable for one operating cycle, cycle 9, only.

(3) Leave in service any predominately axially oriented ODSCC, which has a bobbin voltage less than 3 volts, in the tube at the TSPs C, F, and J intersections.

(4) Repair tubes with ODSCC indications in TSPs C, F, and J that have a bobbin voltage greater than 3 volts.

(5) Inspect all tubes in TSPs C, F, and J intersections using a bobbin coil probe.

(6) Repair and notify the NRC before restart all circumferential indications detected in TSPs C, F, and J intersections.

(7) Exclude from the 3-volt ARC 15 thermally-treated alloy 600 tubes in SG D.

(8) Repair and notify the NRC before restart all axial ODSCC indications outside the thickness of TSPs C, F, and J.

(9) Inspect, with a rotating pancake coil (RPC), axial ODSCC indications having a bobbin voltage greater than 3 volts detected at the intersections of TSPs C, F, and J.

(10) Inspect, with a RPC, mixed residual bobbin signals detected at intersections of TSPs C, F, and J that could potentially mask flaw responses near, or above the voltage repair limits.

(11) Inspect, with a RPC, 100 intersections in TSPs C, F, and J that have bobbin indications less than or equal to 3 volts.

(12) Inspect, with a RPC, mechanically-induced dent signals greater than 5 volts detected at intersections of TSPs C, F, and J.

(13) Use larger of two prior cycles growth rate in the operational assessment.

(14) Submit a condition and operational assessment of SGs 90 days after the plant restart.

(15) Notify the NRC if licensed limits or conditions are exceeded before restarting the unit. The limits and conditions are specified in either the existing TS 4.4.5.5.d or proposed additions to TS 4.4.5.5.d which are discussed in section 4.0 of this safety evaluation.

(16) If one or more indications are confirmed to extend beyond the TSPs, the 3-volt ARC will not be used, except when the condition(s) are evaluated and approved by the NRC staff.

2.3.3 SG Internal Inspection

The technical basis of the 3-volt ARC assumes that axial ODSCC indications are constrained within the TSP intersections and that TSP displacement is limited during a MSLB event. STPNOC preformed analyses to determined the loads placed on each TSP and the resulting displacement during normal operating and accident events. The analysis takes credit for specific SG internal components to provide a load path that limits TSP displacement. To support the technical basis, the load path components and TSPs must be shown to be free of defects and that periodic inspection of the load path components is needed to ensure that structural integrity of the components is maintained.

NRC has issued several communications concerning degradation in steam generator internals and associated inspections. Information Notice 96-09 and associated supplement 1 discussed damages in SG internals in international nuclear plants. GL 97-06 requested licensees to provide inspection plans for degradations in SG internals.

In a letter dated March 30, 1998, STPNOC discussed its SG internal inspection at STP Units 1 and 2 in a response to GL 97-06. For STP Unit 2, STPNOC performed the following inspections for the SG internals during refueling outage 3: (1) visually inspected entire TSPs for ligament cracking in SGs 2A, 2B, 2C and partial TSPs in SG 2D, (2) visually inspected peripheral row/column tube penetration crevices and ligaments of each baffle plates in the preheater in all four SGs, (3) visually inspected wedges, support block and associated welds of preheater baffle plates in SGs 2B, 2C, and 2D, (4) visually inspected tack welds on stayrods in baffle plates in SGs 2B, 2C and 2D, (5) visually inspected wedge welds in flow distribution baffle plates in SG 2B, (6) visually inspected two halves of the flow distribution baffle plates in SGs 2A, 2C, and 2D, and (7) visually inspected wrapper/shell alignment, wrapper welds in SGs 2B, 2C, and 2D.

For STP Unit 1 internals, STPNOC performed the following inspections: (1) inspected about 60 percent of the TSP intersections for ligament cracking using a bobbin coil probe in refueling outage 7, (2) visually inspected wrapper alignment at refueling outages 1, 3, 5, and 6, and (3) at refueling outage 5, visually inspected the flow distribution plate and its patch plate welds; preheater baffle plates and associated welds, stay rods and associated tack welds.

STPNOC reported that no degradation was found in internals nor TSPs in STP Unit 1 and STP Unit 2 SGs. The TSPs in STP Unit 1 SGs are made of carbon steel. The corrosion and

cracking performance of the carbon steel TSPs should bound the performance of the stainless steel TSPs in STP Unit 2 SGs, given similar operating factors between two units. STPNOC concluded that because Unit 1 TSPs have been defect-free, the likelihood of degradation in the STP Unit 2 TSPs should be small. STPNOC proposed not to inspect the SG internals at the upcoming refueling outage 8.

Commonwealth Edison inspected TSPs in Byron/Braidwood model D4 SGs using the bobbin probe. Commonwealth Edison also inspected visually the anti-rotation keys and patch plate seams, over 150 welds on vertical support bars, 9 of 11 stayrod nuts and their tack welds, 7 of 11 spacers between the 8th and 9th TSPs, and 5 TSP wedges. No degradation was found in SG internals at Byron/Braidwood units.

The staff finds that the results from previous steam generator internal inspections at STP Units 1 and 2, and Byron/Braidwood stations provide reasonable assurance of the structural integrity of the load path components and TSPs for STP Unit 2. Considering one operating cycle application for the 3-volt ARC proposed for STP Unit 2, the staff finds that the likelihood of load path components and TSPs being degraded in one operating cycle is small even if the SG internals in Unit 2 are not inspected during refueling outage 8. However, the staff believes that if long-term (i.e., more than one cycle of application) implementation of the 3-volt ARC were considered, it is necessary to develop a plan to address the long-term integrity and inspection of the SG internal structural components and TSPs.

2.3.4 Tube Expansion Installation

2.3.4.1 Installation Procedures

As a part of 3-volt ARC implementation, STPNOC will install expansion joints on 16 tubes at various intersections of TSP C, F, and J. STPNOC stated that before expansion, candidate tubes will be inspected by a bobbin coil probe. Also, a plus point probe will be used to inspect the expansion transition at the top of the tubesheet of the candidate tubes. Potential indications at TSP C, F, and J found by the bobbin inspection will be inspected by a plus point probe. STPNOC specifies that the candidate tubes must have no circumferential indication at the expansion transition, no indication within one inch above or below the TSP and no plus point confirmed bobbin indications greater than one bobbin volt within the confines of the TSP. After an acceptable inspection of the candidate tubes, a sleeve is inserted into the tubes at the designated TSP intersections. The tube expansion is performed using a hydraulic expansion equipment for sleeve expansion with a modified sleeve delivery mandrel and a bladder. The mandrel has an integral eddy current coil that locates the center of the TSP, and positions the center of the sleeve with the center of the bladder. Once the bladder and sleeve are positioned at the correct location, the expansion is generated by supplying high pressure water to the bladder to make the joint. The expansion process is computer controlled for consistency and repeatability.

During the expansion, the sleeve initially yields and contacts the tube. As the sleeve presses the tube, a computer controls the applied pressure by monitoring deflection slope between successive data collection points. The expansion is complete when the prescribed time period has been achieved. The installation procedure was qualified by tests on mockups. STPNOC prepared test specimens at various expansion pressures to establish a relationship between expansion pressure and projected tube outside diameter and to establish a relationship between tube outside diameter and resistive load capability at varying TSP deflection levels.

After the expansion joints are installed, STPNOC will inspect the expansion diameter to ensure that the minimum stiffness requirements are met. STPNOC will use a standard bobbin profilometry probe to determine the mean diameter of the expansion above and below the TSP. The bobbin coil probe will use differential and absolute modes at multiple frequencies, ranging from 10 kHz to 630 kHz. The lowest frequency will be used to locate the SG landmarks, such as TSPs. The highest frequency will be used to measure the diameter of the expansion. The bobbin probe is calibrated by a calibration standard which contain the known bulge diameter. The measurement tests of the bobbin coil probes have showed that the eddy current measurement of the inner diameter of the expansion joints meets the expected value with a small uncertainty. If the diameter requirements are not achieved, additional tubes will be expanded. All expanded tubes will be plugged before service.

2.3.4.2 Structural Integrity of Tube Expansion Joints

STPNOC stated that the interaction between the tube and sleeve in the tube expansion joint provides the rigid link between the tube sections. Even if circumferential cracking is to occur and if the tube is separated at the upper edge of the bulge, the sleeve would provide a rigid structure. With 16 tubes expanded to lock the TSPs, the maximum TSP displacement is estimated to be about 0.048 inch at the peak bounding pressure drop across the TSPs. This displacement is much lower than the designed displacement of 0.3 inch which corresponds to a calculated tube burst probability of less than 1.0E-5. The maximum of three expansions in any tube limits the tube axial tensile stress at the top of the tubesheet that results from expanding the tubes, and minimizes the potential for circumferential cracking at the expansion transition at the top of tubesheet.

The design of the STP Unit 2 expansion joint was modified based on the Braidwood operating experience. The bulge diameter for STP Unit 2 tube expansion joints will be reduced from the expansions made in Byron/Braidwood to lower the residual stress in the expansion joint in STP Unit 2. To compensate the expected loss of load carrying capability from a smaller bulge, a full wall thickness sleeve will be installed in the STP Unit 2 tube instead of the thinner sleeve used in the Braidwood tubes.

STPNOC indicated that a finite element analysis of the expansion effects for application of the process at Byron/Braidwood was performed (reference 6). This evaluation concluded that the TSP ligaments would not be yielded by the expansion process.

After one cycle of operation with the 3-volt ARC, Commonwealth Edison inspected all TSP expansion joints at Braidwood Unit 1 using a plus point coil probe. No indications were detected. A larger bulge has higher potential for developing circumferential flaws than a smaller bulge. STPNOC stated that because there were no circumferential flaws detected at Braidwood Unit 1 after one cycle, and smaller bulges will be installed at STP Unit 2, circumferential cracking is not an issue for the single cycle of operation planned for STP Unit 2.

After one operating cycle, Commonwealth Edison identified circumferential indications at the top of tubesheet region at Braidwood Unit 1. Commonwealth Edison concluded that the circumferential indications were likely undetected indications from the prior inspection that had grown to detectable indications at the roll transition region. The tube-to-tubesheet expansions at Braidwood Unit 1 were hard rolled joints. The tube-to-tubesheet expansion at STP Unit 2 are hydraulically expanded joints. The industry experience has shown that hydraulic expanded joints are less susceptible to circumferential cracking than the hard rolled joints. STPNOC

stated that there has not been any circumferential indications found at STP Unit 2 tubesheet expansion joints.

As discussed in the section above, one of the acceptance criterion for a candidate tube is that it must not contain plus point confirmed bobbin indications greater than one bobbin volt within the confines of the TSP. The staff questioned the impact of this criterion on the structural integrity of the expanded tube because this criterion may lead to the expanded tube having an indication with a bobbin voltage of less than 1 volt. STPNOC stated that a 1 volt indication allowed under this criterion is a bobbin Distorted Support Indication (DSI).

STPNOC stated that an DSI will not affect the expansion process nor the axial load carrying capacity of the tube. If the crack is assumed to be through-wall and to tear, the length of the flaw would be much less than the 0.75 inch span of the TSP, and thus, would not affect the expansion bulges above and below the TSP. If it is not a through wall crack within the TSP thickness, the ductility of the material and the TSP would prevent tearing of the flaw. The crack will not affect the load capacity of the tube because the load carrying capacity depends on the tube cross section and the acceptable expansions. STPNOC indicated that in the final step of the expansion process, the expanded tube will be inspected by a bobbin coil probe for the correct expansion. The bobbin probe will be able to detect tearing in the bulge. If a tear is detected in a bulge, an adjacent alternate tube will be selected for expansion. The staff considers that having a 1-volt DSI in the expanded tube for one cycle of 3-volt ARC application is acceptable because a small flaw in a tube within the TSP should not affect the tube expansion process above and below the TSP and because a small ODSCC flaw will not affect the axial load carrying capacity of the tube. However, for a long-term application of the expanded tube with a 1-volt DSI, the expanded tube should be inspected regularly.

On the basis of operating experience at Byron/Braidwood stations and improved expansion designs, the staff finds that the structural integrity of the expansion joints proposed for STP Unit 2 tubes is acceptable. The staff noted that for potential long-term implementation of the 3-volt ARC, it would be necessary to develop an inspection plan for the expanded tubes to ensure their long-term structural integrity.

2.3.5 SG Tube Structural Integrity

A SG tube can fail either by an axially oriented through-wall burst (referred to hereafter as an "axial burst failure"), or by severance of the tube caused by axial tensile loads (referred to hereafter as an "axial tensile failure"). The voltage repair limits for the low-voltage (e.g., 1 volt) ARC are based on a free span model as discussed in GL 95-05. The free span model limits the potential for axial burst failures because axial tensile failures are not expected on the basis of operating experience to date. In the free span model, credit is taken for the TSPs in precluding the burst of indications at the TSP intersections under normal operating conditions. No credit is taken for the TSPs reducing either the likelihood of tube burst or reducing tube leakage under transient and postulated accident conditions.

The voltage repair limits for the 3-volt ARC are based on a locked TSP model in which credit is taken for the constraint provided by the TSPs, thereby reducing the likelihood of tube axial burst and leakage under normal operation, transient, and postulated accident conditions. However, as voltage repair limits are raised in the locked TSP model, the possibility that tube degradation may occur over a larger portion of the circumference of the tube at a given TSP elevation is increased; i.e., a circumferential band of closely spaced axial cracks with cellular corrosion and

intergranular attack involvement, may develop. Consequently, a degraded tube that is vulnerable for the axial tensile failure may remain in service under the higher voltage-based repair limits, which is addressed in the development of the 3-volt ARC repair limits.

The deterministic tube repair limits and probabilistic assessments of the potential for axial burst failures and axial tensile failure are considered in the development of the voltage-based ARC. Deterministic and probabilistic structural integrity assessments for the free span model were discussed in the NRC's safety evaluation issued for the 1-volt ARC in license amendment 83. The deterministic and probabilistic structural integrity assessments for the locked TSP model in the 3-volt ARC are discussed below.

2.3.5.1 Deterministic Structural Integrity Assessments

2.3.5.1.1 Deterministic Assessment of Axial Burst Failure

On the basis of its routine SG inspections and the destructive examination of pulled tubes since implementing the 1-volt ARC in STP-1 and STP-2, STPNOC has confirmed that the degradation observed within the crevices of the TSPs is predominately axially oriented ODSCC and occurs on the portion of the tube confined within the thickness of the TSPs. As discussed in GL 95-05, axial burst for the ODSCC indication is not likely to occur by the presence of the TSPs during normal operation. As a result, the guidance in RG 1.121 to maintain a margin of safety of at least 3 against tube rupture during normal operating conditions is inherently satisfied at these ODSCC locations.

During transients and accident conditions the TSPs may displace. The TSP displacements, however, are limited by the locking expansion joints that will be installed in 16 tubes. If the TSP does not displace, axial bursts of the tube would be unlikely because the amount an existing ODSCC indication can open is limited by the diametral gap between the outside diameter of the tubes and the diameter of the TSP holes. By limiting the displacement of the TSPs, the extent of ODSCC degradation exposed outside the TSPs during transients and accident conditions is limited to the amount of the TSP displacements.

In WCAP-15163, Revision 1, STPNOC reported that a TSP displacement of about 0.30 inch would lead to a total tube burst probability of about 1.0E-5 under MSLB conditions. The analysis conservatively assumes that there is a through-wall ODSCC indication in all hot leg TSP intersections. This displacement provides a comparison basis for incremental probability of burst resulting from the TSP displacement. If the TSP displaces less than 0.3 inch and if the displacement occurs at fewer than all of the intersections, the burst probability would be less than 1.0E-5. In the original 3-volt ARC as presented in the February 21, 2000, submittal STPNOC estimated that the TSP displacement is limited to 0.15 inch. The analysis in WCAP-15163, Revision 1, did not consider that the TSPs are locked and the locked TSP model was not presented at the time.

After the staff questioned the validity of its thermal hydraulic analysis, STPNOC proposed the locked TSP model and revised its TSP loading calculations with additional TSP displacements calculated as discussed in Addendum to WCAP-15163. On the basis of the locked TSP model, STPNOC calculated an upper bound TSP displacement of 0.048 inch, using the bounding pressure differential of 3.56 psid. As a comparison, the pressure loading at TSPs C and J would have been 2.35 psid and 1.76 psid, respectively. The displacement of record for the upper limit analysis is 0.18 inch, which was calculated from applying the limiting pressure

differential of 13.3 psid. STPNOC reported a comparative TSP displacement of 0.21 inch which is the upper limit on test data supporting the bounding leak rate for Indications Restricted from Burst (IRB) as discussed in Electric Power Research Institute report TR-107625.

To assess the relationship between axial ODSCC indications and burst pressure, STPNOC has provided a statistical correlation between burst pressure and axial crack length. Without the constraint provided by the TSP, a 0.75-inch free span ODSCC indication with lower bound (95 percent/95 percent) material properties would have a burst pressure near the pressures anticipated during a postulated MSLB. However, if it is postulated that the TSPs have relatively small displacements and cover most of a 0.75-inch indication, the tube burst pressure should be much higher than that of the free span ODSCC indication. STPNOC performed series of burst tests to support such a conclusion.

STPNOC performed burst tests on tube specimens that contain axial through-wall cracks. One set of tests were conducted to determine burst pressure for cracks inside the TSP with various tube-to-TSP clearance and various crack lengths outside of the TSP. The objective for the tests is to quantify the effect of the clearance and of various crack length outside of TSP on the burst pressure. STPNOC studied TSP hole sizes and tolerance as specified in the design drawings for the Model E and Model 51 steam generators. From the study, STPNOC conducted the tests with diametral clearances ranging from 0.011 to 0.023 inch. A diametral gap of 0.023 inch represents an upper 95 percent confidence bound on the expected tube-to-TSP gap. The total crack length was maintained at 0.70 inch with a crack length outside the TSP ranged from 0.15 inch to 0.50 inch. A 0.75-inch thick collar was slipped over the tube specimen at the elevation of the crack to simulate the TSP.

The inside of tube specimens were lined with a bladder and the outside diameter of the bladder was reinforced with a small, 0.002-inch thick, low strength brass foil shim to prevent extrusion of the bladder before tube specimen burst. Once the crack tips in the specimen start to extend and the crack flanks open significantly, the test stops.

The TSP-constrained crack tests showed that all cracks including the longest exposed (outside of TSP) length of 0.50 inch achieve a burst pressure that satisfies safety margin of RG 1.121. The burst tests showed that for the smaller clearance of 0.011 to 0.013 inch, the burst pressure for a long crack with a portion of the crack constrained by the TSP would be similar to that of a free span crack with a total length equal to the exposed length of the constrained crack. Therefore, if the diametral clearance between the tube and the TSP hole is small, i.e., in the order of 0.013 inch or less, the free span burst pressure correlation may be used to evaluated the probability of burst of exposed cracks as a function of the length exposed. For the larger clearances, the burst pressure for a long crack with a portion of the crack constrained by the TSP would be expected to be slightly less than the burst pressure for a free span crack with a total length equal to the exposed length of the constrained test specimens. STPNOC used an adjustment factor that lowers the burst pressure of an indication to account for the larger clearance. The adjustment factor bounds the data in the range of TSP displacement distance.

2.3.5.1.2 Summary Of The Deterministic Axial Burst Structural Integrity

STPNOC's test program showed that the tube burst pressure for an axial crack extending outside the TSPs is a function of the exposed ODSCC crack length outside the TSPs rather than the total ODSCC crack length, and the tube burst pressure for cracks that extend outside the TSP is only slightly reduced at larger than nominal tube-to-TSP diametral gaps when

compared to a postulated free span ODSCC crack of the same length. The staff notes that this testing does not consider the effect of many closely spaced axial cracks which may result in further reductions in the tube burst pressure. Despite this observation, the staff concludes, on the basis of operating experience and the testing to date, that the potential of a burst from a single axial ODSCC indication at a TSP intersection with an exposed length of 0.15 inch is negligible. The operating experience and testing to date indicates that: (1) the tube burst capability is dominated by the length and depth profile of the most limiting ODSCC macrocrack at a TSP intersection; (2) the ODSCC degradation is generally centered in the TSPs rather than at the edge of the TSPs. The staff finds that an acceptable margin against axial burst of a single predominately axially oriented ODSCC indication during normal operating, transient, and postulated accident conditions, is ensured because eddy current inspections ensures that all ODSCC indications remain in those portions of the tube are confined within the TSP thickness.

2.3.5.1.3 Deterministic Assessment Of Axial Tensile Failure

With the higher voltage-based ARC (such as 3-volt ARC), the circumferential involvement of the predominately axially oriented ODSCC indication is greater and the potential for axial tensile failure caused by axial load on a tube increases. The circumferential involvement is caused by the development of the closely spaced axial ODSCC cracks and corrosion due to intergranular attack. To ensure that the ODSCC indications will have adequate margin during normal operating, transient and accident conditions, STPNOC provided two different statistical correlations to relate the axial load carrying capability of a predominantly axially ODSCC indication to the bobbin voltage. One correlation relates the residual cross section with the bobbin voltage; the other correlation relates the axial tensile force for axial separation with the bobbin voltage. The structural limit was determined from these correlations by evaluating them at normal operation, transient, and accident conditions.

The first correlation was a linear first order equation between the non-degraded residual cross section area and the bobbin voltage determined by a standard least-square linear regression analysis. From this regression relationship, a lower 95 percent prediction bound was determined for the non-degraded residual cross section area as a function of bobbin voltage. The lower 95 percent prediction interval was further reduced to account for temperature effects on the tube material properties. Using this reduced lower prediction interval curve, the structural limit was determined for a pressure loading corresponding to three times the normal operating internal pressure consistent with the structural limits in RG 1.121. With this approach, a structural limit of 35 volts would be applicable. A second correlation was developed between the axial load carrying capability and the bobbin voltage. From this correlation, the structural limit can be calculated to be in excess of 100 volts.

To determine the tube repair limit of the record, STPNOC adjusted the more conservative structural limit determined above downward to account for the limited size of the database, potential flaw growth during an operating interval, and to account for uncertainty in the non-destructive examination. STPNOC elected to set the repair limit to 3.0 volts for added conservatism. Accordingly, all ODSCC indications with a bobbin voltage above 3.0 volts will be repaired regardless of rotating pancake coil examination.

2.3.5.1.4 Summary Of Deterministic Axial Tensile Structural Integrity

The statistical correlations of non-degraded residual cross section area to the associated bobbin voltage and the correlation of axial rupture force to the logarithm of the associated

bobbin voltage, indicate acceptable structural limits above 35 volts. The staff agrees with STPNOC's conclusion that additional data are needed to better define this estimate of the voltage-based structural limit. The staff notes that uncertainty and potential non-conservatism are introduced into these statistical correlations through the following sources: (1) using several different methods to calculate the residual cross section area; (2) adjusting the data based on the flow stress and/or ultimate strength of the tube specimens for data normalization; (3) assuming lateral restraint of the tubes; (4) using specimens for which no destructive analyses data were available; (5) using a mean value of the tensile strength for the pulled tube database to normalize the laboratory intergranular attack tube specimens; (6) using the mean value of the ultimate strength for the pulled tube database to normalize the TSP constrained tube burst test data; (7) using nominal tube dimensions; and (8) excluding intergranular attack specimens obtained in a manner consistent with the criteria in GL 95-05 because some tubes have intergranular attack involvement at the TSP elevations (e.g., previously plugged tubes). The staff notes that the statistical correlation between the axial rupture force and the logarithm of the bobbin voltage is the preferred approach for developing this type of correlation. However, the staff also notes that there is a minimal amount of data supporting such a correlation.

In the review of the 3-volt ARC amendment for Byron/Braidwood (reference 4), the staff indicated that the projected maximum end of cycle voltage would be about 14 volts. After one cycle of 3-volt ARC application, in 1996, Commonwealth Edison projected a maximum voltage of 10.5 volts at Braidwood, Unit 1 at the end of cycle 7 (reference 5). These two voltage values are considerably less than the calculated structural limits discussed above. Taking into consideration the projected voltages in Byron/Braidwood and the observation that no tube specimens used in support of the free span model failed as a result of axial tensile loads, the staff concludes that a 3.0 volt repair limit is justified through one cycle of application. However, for potential long-term implementation of the 3-volt ARC, additional data are needed to better define the estimate for the structural limit.

2.3.5.2 Probabilistic Structural Integrity Assessment

A probabilistic analysis of the potential for SG tube ruptures, assuming an MSLB, was performed to supplement the deterministic analyses discussed above. To determine the conditional probability of tube burst given an MSLB, the voltage distribution of indications at the end of cycle must be determined. The methodology for determining the end-of-cycle voltage distribution is discussed in GL 95-05. The application of this methodology under the 1-volt ARC and 3-volt ARC are similar. However, the licensee will determine separate end-of-cycle distributions for the ODSCC indications at various TSP intersections to which the 1-volt ARC and 3-volt ARC are applied.

2.3.5.2.1 Probabilistic Assessment Of Axial Burst Failure

With the 3-volt ARC, STPNOC assumed all hot-leg tubes at the TSP intersections had a 0.75 inch long through-wall crack of which a portion of the crack was exposed outside the TSP by the displacement of the TSP during a MSLB event. In addition, STPNOC assumed that the diametral gap between the tube and TSP hole for all intersections was at the upper 95 percent confidence bound. This calculation used the burst pressure versus axial crack length correlation with an appropriate reduction in the burst pressure to account for the tube-to-TSP diametral gap. The result was that the probability of axial burst under MSLB conditions was negligibly low (i.e., less than 1.0E-5).

To show the constraining effect of the TSPs, STPNOC generated two correlations relating the axial length of a cracked tube specimen to the burst pressure of the specimen as discussed in WCAP-15163, Revision 1. The first correlation is a free span correlation which relates the burst pressure of a tube specimen to the total through-wall crack length. The second correlation is one taking credit for the constraint provided by a TSP and which relates the burst pressure of a tube specimen to the through-wall crack length outside the TSP (i.e., the exposed through-wall crack length). From these correlations, the tube burst probability is estimated based on the TSP displacements to determine the magnitude of exposure, the correlation of the burst pressure of free span ODSCC indications to bobbin voltage, and the correlation of the burst pressure of free span ODSCC indications to crack length.

For tubes in which a portion of the length of the indication is restrained in the TSP, STPNOC observed that the burst pressure of the indication correlates with the exposed crack length. The local condition for burst is the critical opening of the crack at the crack tip. For through-wall cracks in thin walled tubing, the critical crack tip opening displacement is about the thickness of the tube. The clearance between the tube and the TSP hole is not sufficient to allow the critical crack to open within the TSP at the pressure which would lead to the burst of cracks of significant length. The crack inside the TSP would not be expected to extend beyond that associated with less-than-critical blunting of the crack tip. If the clearance approaches zero, there can be no crack tip opening displacement at that end of the crack. If the clearance is large, the crack flank may open and the crack would behave as though it were slightly longer than the exposed length. If the clearance is between the two extremes, the burst pressure may be slightly elevated or depressed depending on the clearance.

STPNOC reported that the probability of axial burst under MSLB conditions for a TSP displacement of 0.15 inch was negligibly low. Even if the TSP displacement were to be as large as 0.30 inches, the axial burst probability under MSLB conditions will be on the order of 1.0E-5. STPNOC stated that the burst probability of 1.0E-5 will be used for the end of cycle projection in the condition monitoring and operational assessments even though actual projected burst probability will be much lower than 1.0E-5. This value is low compared to the GL 95-05 reporting threshold of 1.0E-2. STPNOC stated that because of low burst probability and the burst probability of 1.0E-5 will be used, there is no need to calculate burst probability for the condition monitoring and operational assessments for ODSCC indications covered under the 3-volt ARC.

During its review, the staff questioned STPNOC regarding the likelihood of ODSCC indication extending outside the TSP. STPNOC reported that there have been seven indications that have extended outside of the TSP. This data was obtained from the destructive examination of 210 tube-to-TSP intersections from pulled tubes since the beginning of the voltage-based ARC program. The exposed lengths have ranged from 0.025 to 0.27 inch with average depths up to 25 percent through-wall (for an indication with an exposed length of 0.11 inch) and maximum depths up to 50 percent through-wall (for the same indication). There are 14,553 hot leg intersections in the STP Unit 2 SGs that will be covered by the 3-volt ARC. Applying the ratio of 7 indications out of 210 cases to 14,553 intersections, there will be potentially 509 intersections in which ODSCC would extend outside the TSP thickness. If the depth of each of the 509 indications is assumed to be 100 percent through wall for about half the maximum observed length of the crack (i.e., 0.15 inch), and the lengths are added to the maximum predicted TSP displacement of 0.18 inch, STPNOC estimated a cumulative probability of at least one tube burst during a postulated MSLB event to be 1.2E-6. STPNOC stated that this probability satisfies the reporting threshold of 1.0E-2 in GL 95-05.

2.3.5.2.2 Summary Of the Probabilistic Assessment of Axial Burst Structural Integrity

STPNOC has set a tube burst probability of 1.0E-5 for the condition monitoring and operational assessments. This probability is based on conservative assumptions that all intersections in all TSPs had through-wall cracks extending throughout the 0.75-inch thickness of the TSP of which 0.30 inch would be exposed during a postulated MSLB. STPNOC has shown that if the exposed length is 0.15 inch, the tube burst probability would be negligible. Considering that the TSP displacement will be limited to less than 0.15 inch by the expansion joints installed in the 16 tubes, the staff concludes that the likelihood of an axial burst failure, given an MSLB, exceeding the burst probability of 1.0E-5 is extremely low. On this basis, the staff finds that burst probability calculation for the 3-volt ARC is not needed in the condition monitoring and operational assessments and that a reporting burst probability of 1.0E-5 is adequate. It should be noted that, the tube burst probability for those ODSCC indications covered under the existing 1-volt ARC will be calculated. In the condition and operational assessments, STPNOC will combine the tube burst probability of 1.0E-5 from the 3-volt ARC with the tube burst probability calculated under 1-volt ARC. The total burst probabilities must be lower than the reporting threshold of 1.0E-2 as specified in GL 95-05.

However, the staff has concerns regarding flaws extending outside of the TSPs. As stated in GL 95-05, the ARC for ODSCC indications are applicable only to cracks that are fully confined within the TSPs. GL 95-05 was based, in part, on experience that ODSCC on the tubing inside TSPs had not produced cracks with significant extensions into the free span. Seven minor ODSCC indications that extended outside the TSPs that were identified by destructive examination in the 210 pulled tube specimens (discussed in Section 2.3.5.2.1 of this safety evaluation) were not significant to structural or risk considerations. No extensions have been detected by eddy current inspection. However, if ODSCC cracks extending into the free span are detected by future inspections, they will most likely be of structural significance and require assessments. In addition, they would invalidate the staff's technical basis for concluding that there was no significant risk associated with the use of the 3-volt ARC. There is currently no approved method for performing an operational assessment of ODSCC cracks detected to extend beyond the TSPs. Developing an appropriate means for performing an acceptable operational assessment would need to be risk-informed, and its implementation would require additional staff review and approval.

To resolve the staff's concerns, STPNOC added the following requirement to the TSs: "...If one or more indications in the tube support plate intersections are confirmed by non-destructive examination to extend beyond the edge of the tube support plate, the 3-volt alternate repair criteria shall not be used in any steam generator. Exceptions to this requirement may be allowed for those indications that are determined by the NRC staff to be physically insignificant for the purposes of safety and risk assessment. Approval for the use of 3-volt alternate repair criteria may be granted by the staff in writing on a one time basis, following the staff review and consideration of factors related to the crack extensions that are found..."

The staff considers this TS requirement adequate to resolve this potential issue.

2.3.5.2.3 Probabilistic Assessment Of Axial Tensile Failure

In WCAP-15163, STPNOC referenced the probabilistic assessments of axial tensile failure in the 3-volt ARC application for Byron/Braidwood, which is applicable to STP Unit 2. STPNOC

reported the conditional probability of axial tensile failure, given an MSLB, for a single indication using the following two different correlations: (1) the residual cross section area versus bobbin voltage correlation; and (2) the tensile force versus the logarithm of the bobbin voltage correlation. The probability calculation results indicated that conditional probability of axial tensile failure was on the order of 3.0E-5 for the residual cross section area correlation and 3.0E-6 for the tensile force correlation for a single 10 volt indication under MSLB conditions. For this probability to significantly contribute to the overall probability of tube failure in general, there would need to be a significant number of indications greater than 10 volts. As a result of these low probabilities and the low likelihood of developing a large number of 10-volt ODSCC indciations, STPNOC concluded that the axial tensile burst probability given an MSLB is insignificant and need not be calculated. STPNOC's basis for its position involves examining the conditional probability of axial tensile burst of a single ODSCC indication under MSLB conditions (which was evaluated deterministically).

2.3.5.2.4 Summary Of The Probabilistic Axial Tensile Structural Integrity

Byron/Braidwood units implemented the 3-volt ARC for at least two operating cycles. After one cycle of 3-volt ARC application, Commonwealth Edison projected 0.3 ODSCC indications greater than 10 volts at the end of cycle 7 for Braidwood Unit 1. On the basis of low probabilities of axial tensile failure and the low number of predicted ODSCC indications greater than 10 volts, the NRC staff concludes that the axial tensile failure conditional probability will not contribute significantly to the total tube failure probability when compared to the screen threshold value of 1.0E-2 in GL 95-05. The NRC staff finds that calculation of the conditional probability of axial tensile failure is small and need not be performed, provided that: (1) the end of cycle projections are found to be conservative in terms of the size and number of indications; (2) all indications detected are less than 15 volts; and (3) less than 250 indications above 10 volts are observed. The NRC staff notes that the database and correlations supporting this conclusion need to be continually assessed, including the end-of-cycle voltage distributions, to ensure probability of axial tensile burst given an MSLB will remain negligible. While the staff notes that this 3-volt amendment is being approved for only one cycle, if the licensee were to request long-term implementation of the 3-volt ARC, the NRC staff concludes that (1) calculations should be performed in accordance with the methodology described in GL 95-05 (i.e., a probabilistic Monte Carlo analysis), (2) any future submittals proposing to use the locked TSP model should address a means of combining the axial burst and the axial tensile failure conditional probabilities, and (3) the effect on the burst pressure of multiple indications extending outside the TSP needs to be assessed.

2.3.6 Leakage Integrity Assessment

Under the 3-volt ARC, tubes with through-wall or near through-wall cracks may remain in service, thereby creating the potential for primary-to-secondary tube leakage during normal operating, transient, or postulated accident conditions. Accordingly, the leakage integrity of degraded tubes under the 3-volt ARC must be evaluated. The staff believes that acceptable leakage integrity of a tube during normal operating conditions is reasonably assured by implementing the appropriate limits on allowable primary-to-secondary leakage in plant TS. The leakage integrity during transients and postulated accidents is acceptable when the resulting leakage will not exceed a rate that will result in offsite radiation dose limits exceeding requirements in 10 CFR Part 100.

2.3.6.1 Normal Operational Leakage

STPNOC has implemented a primary-to-secondary leakage limit of 150 gallons per day per any one SG in the plant TS. The staff finds that this limit on operational leakage is acceptable because it provides assurance that a degraded SG tube with a measurable leak will be either repaired or removed from service before developing into a large flaw which would result in an offsite release of radiation which would exceed a small fraction of the guideline radiation limits in 10 CFR Part 100 in the event of an MSLB.

2.3.6.2 Leakage Under Accident Conditions

STPNOC's approaches on leakage calculation is based, in part, on leak rates from a tube with an ODSCC indication confined within the TSP thickness under MSLB conditions, where the tube was expected to burst if the indication was located in the free span portion of the tube. This indication is referred to as an IRB. The IRB is restricted from burst by the TSP, and its leakage is limited by the presence of the TSP to less than the free span leakage for a similar crack.

STPNOC proposed a model for calculating the tube leakage from the faulted SG during a postulated MSLB which consists of the following two major models: (1) a model for predicting the leakage from ODSCC indications assuming that the indications are in the free span (i.e., the free span leakage model) and (2) a model for predicting the leakage from indications which may leak more than predicted by the free span model as a result of the crack opening up to the limits of the tube-to-TSP gap (i.e., tube leakage from IRBs). The free span leakage model methodology follows the guidance in GL 95-05 and has been approved by the staff under the 1-volt ARC in License Amendment No. 83 issued for STP Unit 2 on September 24, 1998.

The proposed methodology for predicting leakage from IRBs under postulated accident conditions that are covered by the 3-volt ARC are as follows:

(a) Determine the end-of-cycle voltage distribution for the ODSCC indications in accordance with GL 95-05.

(b) Determine the free span burst pressure for each of the ODSCC indications.

(c) If the ODSCC indication in Item (b) above was determined to burst under the MSLB differential pressure, the indication is assumed to leak and a bounding IRB leak rate is assigned for this indication. The bounding IRB leakage for STP Unit 2 is 5 gallons per minute (gpm) and is discussed below.

(d) If the ODSCC indication in Item (b) above is determined not to burst under MSLB conditions, (i.e., the tube burst pressure is greater than the differential pressure inside the tube), the free span leakage methodology in GL 95-05 is followed.

(e) Items (b), (c), and (d) above are repeated for all ODSCC indications in the end-of-cycle voltage distribution. The leakage for all ODSCC indications is then summed to determine the total leak rate.

(f) Items (b) through (e) above are repeated in a Monte Carlo simulation to obtain a distribution of leakage.

(g) Obtain the 95 percent confidence bound on the 95th percentile of the total leakage values is determined from the distribution of the leak rates. This leak value is then combined with the leakage value calculated for the ODSCC indications covered under the 1-volt ARC. The total leak rate is then compared to the leak rate limit under an MSLB event for the faulted SG which is 15.4 gallons per minute for STP Unit 2.

2.3.6.3 Tube Leakage Tests

STPNOC performed tests to determine the bounding leak rate and its sensitivity to TSP displacement for through-wall IRB. The leakage testing is also to establish a data base to verify that the leakage from cracks left in service under the 3-volt ARC will be acceptable during MSLB accident conditions. The MSLB conditions are defined in the tests as 615 degrees F primary coolant temperature and a pressure differential of 2560 psid. For STP Unit 2, the MSLB differential pressure is 2405 psid.

STPNOC used tube specimens with various cracks to simulate the ODSCC indications. The longest through-wall crack tested was 0.29 inch (with 0.600 inch total length), which has a bobbin voltage of 11.4 volts. Tests were performed up to a maximum TSP displacement of 0.21 inch in developing the bounding IRB leak rate of 5.0 gpm. STPNOC stated that the through-wall crack lengths that led to the 5.0 gpm IRB leak rate were on the order of 0.6 inch or longer; therefore, the center of the crack limiting the crack opening would be inside the TSP for displacements up to about 0.3 inch.

In 2000, after reviewing burst test data in connection with an operational assessment of a nuclear plant, the NRC staff raised a concern about the validity of the burst correlation developed for the voltage-based repair criteria. The data showed that rapid burst pressure testing for tubes with ODSCC flaws exhibit a strong testing rate effect, i.e., an apparent strength higher than would be found from quasi-static testing. The burst data developed for the voltage-based repair criteria contains tubes tested under very rapid pressurization. Therefore, the burst correlation relied upon for the repair criteria may also exhibit this effect. Structural integrity is governed by a requirement to show a margin of three to the normal operating differential pressure. Normal operating pressure is a steady state condition. Therefore, the margin is based on the same steady state pressure condition, rather than a rapidly changing pressure condition.

Under the 3-volt ARC, the burst probability of an ODSCC indication is low and the margin of three for the normal operation pressure differential is inherently satisfied because of the constraint provided by the TSP. STPNOC stated that the leak rate tests for the IRB was performed in a high temperature range and at MSLB pressure. The tube specimens were pressurized slowly in order to reach the MSLB pressure; therefore, the slow pressurization rate in the IRB leak tests does not affect the strength of the IRB test specimens. In addition, any ODSCC indications that will remain in service will be precluded from burst because of the constraint provided by the TSPs. The staff concludes that the generic issue relating to the pressurization rate does not affect the technical basis of the 3-volt ARC.

3.6.4 Summary of Leakage Integrity

The NRC staff concludes that for the 3-volt ARC for one operating cycle, the bounding 5.0 gpm leak rate for IRBs predicted to burst below MSLB differential pressure, is appropriate. However,

the NRC staff is still evaluating the acceptability of the IRB leak rate value for long-term implementation. The NRC staff's review of this matter will determine if additional conservatisms should be applied to the 5.0 gpm estimate or if additional testing is required, based on (1) the potential for the severity of the ODSCC degradation at the TSPs to increase over the long-term (e.g., the potential for multiple through-wall cracks to develop near the edges of the TSPs), (2) the NRC staff's continuing review of the leakage adjustment procedure to MSLB conditions, (3) apparent anomalies in some of the laboratory data supporting the 5.0 gpm leak rate estimate, and (4) a review of industry data on this matter.

The staff evaluated STPNOC's proposed methodology for determining the total leak rate from indications at the TSP elevations by summing the contributions of the leakage values from the freespan model and locked TSP model. The NRC staff concludes this is acceptable for only one operating cycle, given the limited number and severity of ODSCC indications to which the freespan model has historically been applied. However, the NRC staff is still evaluating the need for a long-term approach to combine the leakage estimates from the freespan model and locked TSP model, including a contribution from ODSCC indications which burst under the freespan model, prior to ordering the total leakage values. The total leak rate would then be determined by evaluating the ordered array of leak rates at the 95^{th} quantile at a 95 percent confidence level.

2.4 Proposed Changes to TSs

STPNOC proposed the following changes to TS sections to incorporate specific requirements in the 3-volt ARC. The changes also include revisions to the existing 1-volt ARC wording to clarify specific TSPs that will be covered by 1-volt ARC.

TS 4.4.5.2.d This section is revised by adding that all flow distribution baffle plate intersections, the hot leg TSP intersections and the cold-leg tube support intersections will be inspected by a bobbin coil probe. This revision is to identify the specific TSPs that require the bobbin probe inspection.

TS 4.4.5.2.d.1) This section is added to require that all intersections with mechanically induced dent signals greater than 5 volts identified by bobbin coil inspection shall be inspected by a RPC probe (or equivalent).

TS 4.4.5.2.d.2) This section is added to require that all intersections with large mixed residuals that could potentially mask flaw responses at or above the voltage repair limits shall be inspected by a RPC probe (or equivalent).

TS 4.4.5.2.d.3) This section is added to require that tubes with axial ODSCC indications detected at the flow distribution baffle plate intersections, at the cold leg support plate intersections, and at the hot leg support plates L through R intersections under the 1-volt ARC that are greater than the lower voltage repair limit be inspected by a RPC. This revision is added to clarify the potential indications in various TSPs that are covered under the existing 1-volt ARC.

TS 4.4.5.2.d.4) This section is added to require STPNOC to inspect (1) any axial ODSCC indication with a bobbin voltage greater than 3 volts detected in plates C, F, and J by a RPC (or equivalent) probe and (2) 100 axial ODSCC indications in plates C, F, and J with bobbin voltage less than 3 volts by a rotating pancake coil (or equivalent) probe.

TS 4.4.5.4.a.11 This section is revised to limit the 1-volt ARC to TSPs L through R as identified in Figure 1. This revision is to identify specific TSPs that are covered by the 1-volt ARC as oppose to the TSPs that are covered under the 3-volt ARC.

TS 4.4.5.4.a.11.d) Note 2. This note is revised to require that voltage growth rate shall be the larger of the average growth rates experienced in the two prior cycles, but not less than 30 percent per effective full power year. This requirement is taken from GL 95-05 as a part of guidance on how to perform the condition and operational assessments.

TS 4.4.5.4.a.11.d) This section is revised to require that the 3-volt ARC are applicable for Unit 2 operating cycle 9 only. It also clarifies that plates C, F, and J as identified in Figure 1 are covered under the 3-volt ARC.

TS 4.4.5.4.a.11 e) STPNOC inserts this section to state that SG tubes, whose degradation is attributed to axial oriented ODSCC within the bounds of the TSP with a bobbin voltage less than or equal to 3.0 volts, may remain in service.

TS 4.4.5.4.a.11 f) STPNOC inserts this section to state that SG tubes whose degradation is attributed to axial oriented ODSCC within the bounds of the tube support plate with a bobbin voltage greater than 3.0 volts shall be plugged or repaired regardless of whether or not a RPC inspection detects degradation.

TS 4.4.5.4.a.11.g STPNOC inserts the following specification: If one or more indications in the tube support plate intersections are confirmed by non-destructive examination to extend beyond the edge of the tube support plate, the 3-volt alternate repair criteria shall not be used in any steam generator. Exceptions to this requirement may be allowed for those indications that are determined by the NRC staff to be physically insignificant for the purposes of safety and risk assessment. Approval for the use of 3-volt alternate repair criteria may be granted by the staff in writing on a one time basis, following the staff review and consideration of factors related to the crack extensions that are found.

TS 4.4.5.5.d.1).a) This section is added to require that the leakage calculations for axial ODSCC indications covered under the 1-volt ARC shall be performed using the methodology of GL 95-05.

TS 4.4.5.5.d.1).b) This section is added to require that the leakage calculations for axial ODSCC indications detected in plates C, F, and J which are covered under the 3-volt ARC shall be performed using the modified methodology of GL 95-05 as described in WCAP-15163, Revision 1.

TS 4.4.5.5.d.5).a) This section is added to require that the burst probability calculations shall be performed for axial ODSCC indications covered under the 1-volt ARC shall be performed using the methodology of GL 95-05.

TS 4.4.5.5.d.5).b) This section is added to require that under the 3-volt ARC the burst probability for tube(s) having axial ODSCC indications detected in plates C, F, and J will be set at 1.0E-5.

TS 4.4.5.5.d.6) This section is added to require that if cracking is observed in the TSPs under the voltage-based ARC, STPNOC will notify the NRC before restart of the unit.

TS 4.4.5.5.d.7) This section is added to require that if SG internal inspection are conducted and if indications detrimental to the integrity of the load path necessary to support the 3-volt ARC are found, STPNOC will notify the NRC and provide an assessment of the safety significance of the occurrence before restart of the unit.

TS 4.4.5.5.e. This section is added to require STPNOC to submit a report to the NRC that addresses "Information to be Provided Following Each Restart" per GL 95-05, 6.b, within 90 days following outage breaker closure.

Tables 4.4-2 and 4.4-3 Notification to NRC for SG inspection results fall in the C-3 category will be changed from "50.72(b)(2) of 10CFR Part 50" to "10CFR50.72(b)(3)(ii)." This change is proposed to reflect the revision in the latest *Code of Federal Regulations* published on January 23, 2001.

Bases 3/4.4.5, Page B3/4 4-3. This section is revised by adding discussion regarding technical basis for the structural margins for the 1-volt and 3-volts ARC.

The staff concludes that the proposed changes to plant TS are consistent with the proposed 3-volt ARC discussed in section 3.2 of this evaluation and, therefore, are acceptable.

2.5 Summary

The NRC staff has reviewed STPNOC's proposed amendment to implement the 3-volt ARC for SG tubes in the STP Unit 2 TS. The NRC staff concludes that adequate structural and leakage integrity of degraded SG tubing covered under the 3-volt ARC can be assured for Unit 2 Operating Cycle 9. The NRC staff approves the proposed 3-volt repair criteria based, in part, on the TS requirement that precludes the use of the 3-volt ARC methodology if indications are found by nondestructive examination to extend beyond the edge of the tube support plate. The use of the 3-volt ARC requires that STPNOC demonstrates acceptable primary-to-secondary leakage under main steam line break event. On this basis, STPNOC may incorporate the proposed alternate repair criteria into the STP-2 TSs.

The staff notes that additional technical areas in the submittal will need to be addressed before approving the 3-volt ARC for more than one cycle of operation. These areas include, but not necessarily limited to:

(a) The long-term integrity and inspection of the SG internals, including the TSPs.
(b) The long-term integrity and inspection plans of the expanded tubes.
(c) Combining the conditional probability of axial burst and axial tensile failures.
(d) The long-term acceptability of the IRB leakage estimates.
(e) The effects on the burst pressure of multiple indications extending outside the TSP.
(f) The methodology for combining the leakage estimates from the free span model and locked TSP model.

2.6 References

1. Letter from J. J. Sheppard, "Proposed Amendment to South Texas Project Technical Specification 3/4.4.5-Modify Acceptance Criteria for Repair of Steam Generator Tubes at Certain Intersections of Tubes and Tube Support Plates," Letter to NRC, dated February 21, 2000.

2. Letter from J. J. Sheppard, "Supplement to Proposed Amendment to South Texas Project Technical Specification 3/4.4.5-Modify Acceptance Criteria for Repair of Steam Generator Tubes at Certain Intersections of Tubes and Tube Support Plates TAC No. MA8271," Letter to NRC, dated January 24, 2001.

3. Letter from J. J. Sheppard, "Response to Request for Additional Information re: License Amendment Request Associated with Modifying Alternate Repair Criteria of Steam Generator Tubes at Certain Intersections of Tubes and Tube Support Plates (TAC No. MA8271)," Letter to NRC, dated January 30, 2001.

4. Letter from M. D. Lynch of NRC to D. L. Farrar of Commonwealth Edison, subject : Issuance of Amendments, dated November 9, 1995

5. Letter from M. D. Lynch of NRC to I. M. Johnson of Commonwealth Edison, subject: Issuance of Amendments (TAC NOS. M96498, M96499, M96500 AND M96501), dated May 14, 1997

6. WCAP-14273, "Technical Support for Alternate Plugging Criteria with Tube Expansion at Tube Support Plate Intersections for Braidwood 1 and Byron 1 Model D4 Steam Generators," Westinghouse Electric Company, February 1995.

7. Letter from J. J. Sheppard, "Change to Supplement to Proposed Technical Specification 3/4.4.5-Amendment (TAC No. MA8271), letter to NRC, dated February 28, 2001.

3.0 STATE CONSULTATION

In accordance with the Commission's regulations, the Texas State official was notified of the proposed issuance of the amendments. The State official had no comments.

4.0 ENVIRONMENTAL CONSIDERATION

The amendment changes a requirement with respect to the installation or use of a facility component located within the restricted area as defined in 10 CFR Part 20. The NRC staff has determined that the amendment involves no significant increase in the amounts and no significant change in the types of any effluents that may be released offsite, and that there is no significant increase in individual or cumulative occupational radiation exposure. The Commission has previously issued a proposed finding that the amendment involve no significant hazards consideration, and there has been no public comment on such finding (65 FR 15386). Accordingly, the amendment meets the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Pursuant to 10 CFR 51.22(b), no environmental impact statement or environmental assessment need be prepared in connection with the issuance of the amendment.

5.0 CONCLUSION

The Commission has concluded, based on the considerations discussed above, that (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, (2) such activities will be conducted in compliance with the Commission's regulations, and (3) the issuance of the amendment will not be inimical to the common defense and security or to the health and safety of the public.

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Date: March 8, 2001

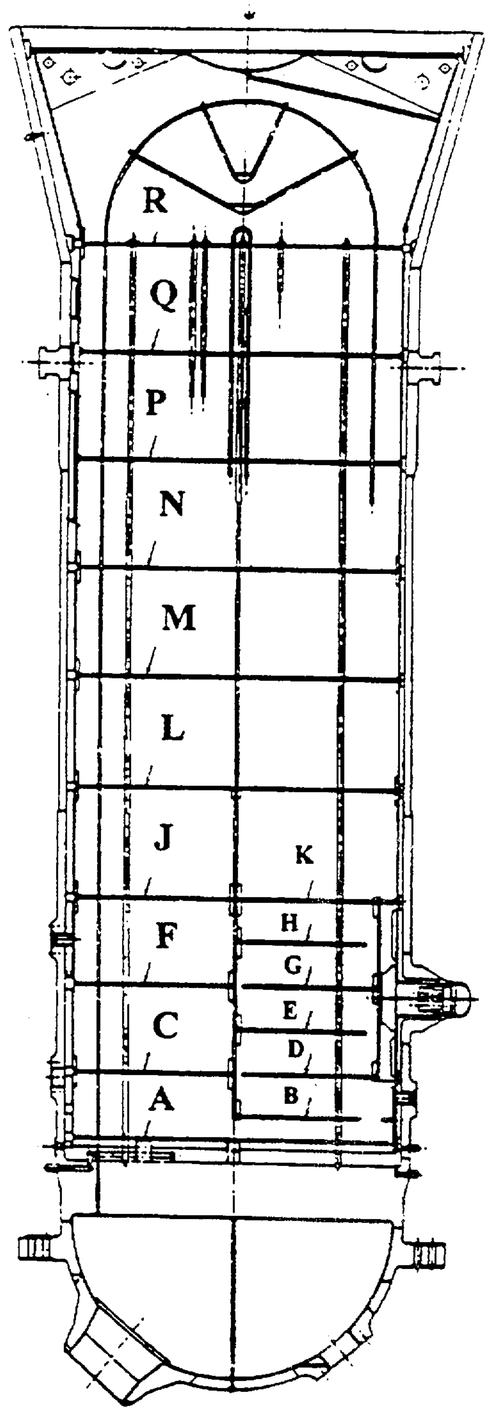

Figure 1 TSP Letter Designations