



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

November 5, 2012

Mr. Mano Nazar  
Executive Vice President and  
Chief Nuclear Officer  
Florida Power and Light Company  
P.O. Box 14000  
Juno Beach, Florida 33408-0420

**SUBJECT: TURKEY POINT NUCLEAR GENERATING STATION UNIT NOS. 3 AND 4 -  
ISSUANCE OF AMENDMENTS REGARDING PERMANENT ALTERNATE  
REPAIR CRITERIA FOR STEAM GENERATOR TUBES  
(TAC NOS. ME8515 AND ME8516)**

Dear Mr. Nazar:

The U.S. Nuclear Regulatory Commission has issued the enclosed Amendment No. 254 to Renewed Facility Operating License No. DPR-31 and Amendment No. 250 to Renewed Facility Operating License No. DPR-41 for the Turkey Point Nuclear Generating Station (TPN), Unit Nos. 3 and 4, respectively. The amendments consist of changes to the Technical Specifications (TSs) in response to your application dated April 30, 2012, as supplemented by letters dated October 10 and 18, 2012.

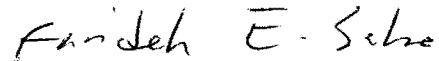
The amendments revise TS 6.8.4.j, "Steam Generator (SG) Program," and TS 6.9.1.8, "Steam Generator Tube Inspection Report." The changes establish permanent SG tube alternate repair criteria for tubing flaws located in the lower region of the tubesheet and accompanying inspection and reporting requirements. The alternate repair criteria replace previous temporary alternate repair criteria and accompanying inspection and reporting requirements for TPN Unit Nos. 3 and 4.

M. Nazar

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

Sincerely,

A handwritten signature in black ink that reads "Farideh E. Saba". The signature is written in a cursive style with a clear, legible font.

Farideh E. Saba, Senior Project Manager  
Plant Licensing Branch II-2  
Division of Operating Reactor Licensing  
Office of Nuclear Reactor Regulation

Docket Nos. 50-250 and 50-251

Enclosures:

1. Amendment No. 254 to DPR-31
2. Amendment No. 250 to DPR-41
3. Safety Evaluation

cc w/enclosures: Distribution via Listserv



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

FLORIDA POWER AND LIGHT COMPANY

DOCKET NO. 50-250

TURKEY POINT NUCLEAR GENERATING STATION UNIT NO. 3

AMENDMENT TO RENEWED FACILITY OPERATING LICENSE

Amendment No. 254  
Renewed License No. DPR-31

1. The Nuclear Regulatory Commission (the Commission) has found that:
  - A. The application for amendment by Florida Power and Light Company (the licensee) dated April 30, 2012, as supplemented by letters dated October 10 and 18, 2012, 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, 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 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.

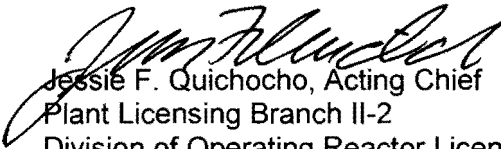
2. Accordingly, the license is amended by changes to the Technical Specifications as indicated in the attachment to this license amendment, and paragraph 3.B of Renewed Facility Operating License No. DPR-31 is hereby amended to read as follows:

B. Technical Specifications

The Technical Specifications contained in Appendix A, as revised through Amendment No. 254 are hereby incorporated into this renewed license. The Environmental Protection Plan contained in Appendix B is hereby incorporated into this renewed license. The licensee shall operate the facility in accordance with the Technical Specifications and the Environmental Protection Plan.

3. This license amendment is effective as of its date of issuance and shall be implemented prior to entering COLD SHUTDOWN conditions for refueling outage 27.

FOR THE NUCLEAR REGULATORY COMMISSION

  
Jessie F. Quichocho, Acting Chief  
Plant Licensing Branch II-2  
Division of Operating Reactor Licensing  
Office of Nuclear Reactor Regulation

Attachment:  
Changes to the Operating License  
and Technical Specifications

Date of Issuance: November 5, 2012



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

FLORIDA POWER AND LIGHT COMPANY

DOCKET NO. 50-251

TURKEY POINT NUCLEAR GENERATING STATION UNIT NO. 4

AMENDMENT TO RENEWED FACILITY OPERATING LICENSE

Amendment No. 250  
Renewed License No. DPR-41

1. The Nuclear Regulatory Commission (the Commission) has found that:
  - A. The application for amendment by Florida Power and Light Company (the licensee) dated April 30, 2012, as supplemented by letter dated October 10 and 18, 2012, 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, 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 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.

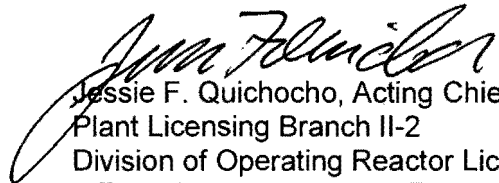
2. Accordingly, the license is amended by changes to the Technical Specifications as indicated in the attachment to this license amendment, and paragraph 3.B of Renewed Facility Operating License No. DPR-41 is hereby amended to read as follows:

B. Technical Specifications

The Technical Specifications contained in Appendix A, as revised through Amendment No. 250 are hereby incorporated into this renewed license. The Environmental Protection Plan contained in Appendix B is hereby incorporated into this renewed license. The licensee shall operate the facility in accordance with the Technical Specifications and the Environmental Protection Plan.

3. This license amendment is effective as of its date of issuance and shall be implemented prior to entering COLD SHUTDOWN conditions for refueling outage 27.

FOR THE NUCLEAR REGULATORY COMMISSION

  
Jessie F. Quichocho, Acting Chief  
Plant Licensing Branch II-2  
Division of Operating Reactor Licensing  
Office of Nuclear Reactor Regulation

Attachment:  
Changes to the Operating License  
and Technical Specifications

Date of Issuance: November 5, 2012

ATTACHMENT TO LICENSE AMENDMENT

AMENDMENT NO. 254 RENEWED FACILITY OPERATING LICENSE NO. DPR-31

AMENDMENT NO. 250 RENEWED FACILITY OPERATING LICENSE NO. DPR-41

DOCKET NOS. 50-250 AND 50-251

Replace Page 3 of Renewed Operating License DPR-31 with the attached Page 3.

Replace Page 3 of Renewed Operating License DPR-41 with the attached Page 3.

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

Remove pages

6-18a  
6-18b  
6-22a

Insert pages

6-18a  
6-18b  
6-22a

- E. Pursuant to the Act and 10 CFR Parts 40 and 70 to receive, possess, and use at any time 100 milligrams each of any source or special nuclear material without restriction to chemical or physical form, for sample analysis or instrument calibration or associated with radioactively contaminated apparatus;
  - F. Pursuant to the Act and 10 CFR Parts 30 and 70, to possess, but not separate, such byproduct and special nuclear materials as may be produced by the operation of Turkey Point Units Nos. 3 and 4.
3. This renewed operating license shall be deemed to contain and is subject to the conditions specified in the following Commission regulations: 10 CFR Part 20, Section 30.34 of 10 CFR Part 30, Section 40.41 of 10 CFR Part 40, Sections 50.54 and 50.59 of 10 CFR Part 50, and Section 70.32 of 10 CFR Part 70; and is subject to all applicable provisions of the Act and to the rules, regulations, and orders of the Commission now or hereafter in effect, and is subject to the additional conditions specified below:
- A. Maximum Power Level

The applicant is authorized to operate the facility at reactor core power levels not in excess of 2644 megawatts (thermal).
  - B. Technical Specifications

The Technical Specifications contained in Appendix A, as revised through Amendment No. 254 are hereby incorporated into this renewed license. The Environmental Protection Plan contained in Appendix B is hereby incorporated into this renewed license. The licensee shall operate the facility in accordance with the Technical Specifications and the Environmental Protection Plan.
  - C. Final Safety Analysis Report

The licensee's Final Safety Analysis Report supplement submitted pursuant to 10 CFR 54.21(d), as revised on November 1, 2001, describes certain future inspection activities to be completed before the period of extended operation. The licensee shall complete these activities no later than July 19, 2012.

The Final Safety Analysis Report supplement as revised on November 1, 2001, described above, shall be included in the next scheduled update to the Final Safety Analysis Report required by 10 CFR 50.71(e)(4), following the issuance of this renewed license. Until that update is complete, the licensee may make changes to the programs described in such supplement without prior Commission approval, provided that the licensee evaluates each such change pursuant to the criteria set forth in 10 CFR 50.59 and otherwise complies with the requirements in that section.



- E. Pursuant to the Act and 10 CFR Parts 40 and 70 to receive, possess, and use at any time 100 milligrams each of any source or special nuclear material without restriction to chemical or physical form, for sample analysis or instrument calibration or associated with radioactively contaminated apparatus;
  - F. Pursuant to the Act and 10 CFR Parts 30 and 70, to possess, but not separate, such byproduct and special nuclear materials as may be produced by the operation of Turkey Point Units Nos. 3 and 4.
3. This renewed operating license shall be deemed to contain and is subject to the conditions specified in the following Commission regulations: 10 CFR Part 20, Section 30.34 of 10 CFR Part 30, Section 40.41 of 10 CFR Part 40, Sections 50.54 and 50.59 of 10 CFR Part 50, and Section 70.32 of 10 CFR Part 70; and is subject to all applicable provisions of the Act and to the rules, regulations, and orders of the Commission now or hereafter in effect, and is subject to the additional conditions specified below:
- A. Maximum Power Level  

The applicant is authorized to operate the facility at reactor core power levels not in excess of 2644 megawatts (thermal).
  - B. Technical Specifications  

The Technical Specifications contained in Appendix A, as revised through Amendment No. 250 are hereby incorporated into this renewed license. The Environmental Protection Plan contained in Appendix B is hereby incorporated into this renewed license. The licensee shall operate the facility in accordance with the Technical Specifications and the Environmental Protection Plan.
  - C. Final Safety Analysis Report  

The licensee's Final Safety Analysis Report supplement submitted pursuant to 10 CFR 54.21(d), as revised on November 1, 2001, describes certain future inspection activities to be completed before the period of extended operation. The licensee shall complete these activities no later than April 10, 2013.

The Final Safety Analysis Report supplement as revised on November 1, 2001, described above, shall be included in the next scheduled update to the Final Safety Analysis Report required by 10 CFR 50.71(e)(4), following the issuance of this renewed license. Until that update is complete, the licensee may make changes to the programs described in such supplement without prior Commission approval, provided that the licensee evaluates each such change pursuant to the criteria set forth in 10 CFR 50.59 and otherwise complies with the requirements in that section.

## ADMINISTRATIVE CONTROLS

### PROCEDURES AND PROGRAMS (Continued)

- b. Performance criteria for SG tube integrity. SG tube integrity shall be maintained by meeting the performance criteria for tube structural integrity, accident induced leakage, and operational leakage.
1. Structural integrity performance criterion: All in-service SG tubes shall retain structural integrity over the full range of normal operating conditions (including startup, operation in the power range, hot standby, and cooldown and all anticipated transients included in the design specification) and design basis accidents. This includes retaining a safety factor of 3.0 against burst under normal steady state full power operation primary-to-secondary pressure differential and a safety factor of 1.4 against burst applied to the design basis accident primary-to-secondary pressure differentials. Apart from the above requirements, additional loading conditions associated with the design basis accidents, or combination of accidents in accordance with the design and licensing basis, shall also be evaluated to determine if the associated loads contribute significantly to burst or collapse. In the assessment of tube integrity, those loads that do significantly affect burst or collapse shall be determined and assessed in combination with the loads due to pressure with a safety factor of 1.2 on the combined primary loads and 1.0 on axial secondary loads.
  2. Accident induced leakage performance criterion: The primary-to-secondary accident induced leakage rate for any design basis accident, other than SG tube rupture, shall not exceed the leakage rate assumed in the accident analysis in terms of total leakage rate for all SGs and leakage rate for an individual SG. Leakage is not to exceed 0.60 gpm total through all SGs and 0.20 gpm through any one SG at room temperature conditions.
  3. The operational leakage performance criterion is specified in LCO 3.4.6.2, "Reactor Coolant System Operational Leakage."
- c. Provisions for SG tube repair criteria. Tubes found by inservice inspection to contain flaws with a depth equal to or exceeding 40% of the nominal tube wall thickness shall be plugged.

The following alternate tube repair criteria shall be applied as an alternative to the 40% depth based criteria:

1. Tubes with service-induced flaws located greater than 18.11 inches below the top of the tubesheet do not require plugging. Tubes with service-induced flaws located in the portion of the tube from the top of the tubesheet to 18.11 inches below the top of the tubesheet shall be plugged upon detection.

## ADMINISTRATIVE CONTROLS

### PROCEDURES AND PROGRAMS (Continued)

- d. Provisions for SG tube inspections. Periodic SG tube inspections shall be performed. The number and portions of the tubes inspected and methods of inspection shall be performed with the objective of detecting flaws of any type (e.g., volumetric flaws, axial and circumferential cracks) that may be present along the length of the tube, from the tube-to-tubesheet weld at the tube inlet to the tube-to-tubesheet weld at the tube outlet, and that may satisfy the applicable tube repair criteria. The portion of the tube below 18.11 inches from the top of the tubesheet is excluded from inspection. The tube-to-tubesheet weld is not part of the tube. In addition to meeting the requirements of d.1, d.2, and d.3 below, the inspection scope, inspection methods, and inspection intervals shall be such as to ensure that SG tube integrity is maintained until the next SG inspection. An assessment of degradation shall be performed to determine the type and location of flaws to which the tube may be susceptible and, based on this assessment, to determine which inspection methods need to be employed and at what locations.
1. Inspect 100% of the tubes in each SG during the first refueling outage following SG replacement.
  2. Inspect 100% of the tubes at sequential periods of 120, 90, and, thereafter, 60 effective full power months. The first sequential period shall be considered to begin after the first inservice inspection of the SGs. In addition, inspect 50% of the tubes by the refueling outage nearest the midpoint of the period and the remaining 50% by the refueling outages nearest the end of the period. No SG shall operate for more than 48 effective full power months or two refueling outages (whichever is less) without being inspected.
  3. If crack indications are found in any portion of a SG tube not excluded above, then the next inspection for each SG for the degradation mechanism that caused the crack indication shall not exceed 24 effective full power months or one refueling outage (whichever is less). If definitive information, such as from examination of a pulled tube, diagnostic non-destructive testing, or engineering evaluation indicates that a crack-like indication is not associated with a crack(s), then the indication need not be treated as a crack.
- e. Provisions for monitoring operational primary-secondary leakage.
- k. Control Room Envelope Habitability Program

A Control Room Envelope (CRE) Habitability Program shall be established and implemented to ensure that CRE habitability is maintained such that, with an OPERABLE Control Room Emergency Ventilation System (CREVS), CRE occupants can control the reactor safely under normal conditions and maintain it in a safe condition following a radiological event, hazardous chemical release, or a smoke challenge. The program shall ensure that adequate radiation protection is provided to permit access and occupancy of the CRE under design basis accident (DBA) conditions without personnel receiving radiation exposures in excess of 5 rem total effective dose equivalent (TEDE) for the duration of the accident.

The program shall include the following elements:

- a. The definition of the CRE and the CRE boundary.
- b. Requirements for maintaining the CRE boundary in its design condition including configuration control and preventive maintenance.

## ADMINISTRATIVE CONTROLS

### STEAM GENERATOR TUBE INSPECTION REPORT (Cont'd)

6.9.1.8 A report shall be submitted within 180 days after the initial entry into MODE 4 following completion of an inspection performed in accordance with Specification 6.8.4.j, Steam Generator (SG) Program. The report shall include:

- a. The scope of inspections performed on each SG,
- b. Active degradation mechanisms found,
- c. Nondestructive examination techniques utilized for each degradation mechanism,
- d. Location, orientation (if linear), and measured sizes (if available) of service induced indications,
- e. Number of tubes plugged during the inspection outage for each active degradation mechanism,
- f. Total number and percentage of tubes plugged to date,
- g. The results of condition monitoring, including the results of tube pulls and in-situ testing, and
- h. The effective plugging percentage for all plugging in each SG.
  
- i. The primary to secondary leakage rate observed in each SG (if it is not practical to assign the leakage to an individual SG, the entire primary to secondary leakage should be conservatively assumed to be from one SG) during the cycle preceding the inspection which is the subject of the report,
- j. The calculated accident induced leakage rate from the portion of the tubes below 18.11 inches from the top of the tubesheet for the most limiting accident in the most limiting SG. In addition, if the calculated accident induced leakage rate from the most limiting accident is less than 1.82 times the maximum operational primary to secondary leakage rate, the report should describe how it was determined, and
- k. The results of monitoring for tube axial displacement (slippage). If slippage is discovered, the implications of the discovery and corrective action shall be provided.

### SPECIAL REPORTS

6.9.2 Special reports shall be submitted to the Regional Administrator of the Regional Office of the NRC within the time period specified for each report as stated in the Specifications within Sections 3.0, 4.0, or 5.0.



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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION  
RELATED TO AMENDMENT NO. 254 TO  
RENEWED FACILITY OPERATING LICENSE NO. DPR-31 AND  
AMENDMENT NO. 250 TO RENEWED FACILITY OPERATING LICENSE NO. DPR-41  
FLORIDA POWER AND LIGHT COMPANY  
TURKEY POINT NUCLEAR GENERATING STATION UNIT NOS. 3 AND 4  
DOCKET NOS. 50-250 AND 50-251

1.0 INTRODUCTION

By application dated April 30, 2012 (Agencywide Documents Access and Management System Accession No. ML12130A206), as supplemented by letters dated October 10 and 18, 2012 (Reference 2 and 3), Florida Power and Light (the licensee) proposed an amendment to the Technical Specifications (TSs) for Turkey Point Nuclear Generating Station (TPN), Unit Nos. 3 and 4. The proposed amendments would revise TS 6.8.4.j, "Steam Generator (SG) Program," and TS 6.9.1.8, "Steam Generator Tube Inspection Report." The proposed changes would establish permanent SG tube alternate repair criteria for tubing flaws located in the lower region of the tubesheet and accompanying inspection and reporting requirements. The proposed alternate repair criteria would replace previous temporary alternate repair criteria and accompanying inspection and reporting requirements for TPN Units 3 and 4.

The supplements dated October 10 and 18, 2012, provided additional information that clarified the application, did not expand the scope of the application as originally noticed, and did not change the staff's original proposed no significant hazards consideration determination as published in the *Federal Register* on August 7, 2012 (77 FR 47126).

1.1 BACKGROUND

Turkey Point Units 3 and 4 have three Model 44F SGs each, which were designed and fabricated by Westinghouse. There are 3214 thermally treated Alloy 600 (Alloy 600TT) tubes with a nominal outside diameter of 0.875 inches and a nominal wall thickness of 0.050 inches. The thermally treated tubes are hydraulically expanded for the full depth of the 21-inch thick tubesheet and are welded to the tubesheet at each tube end. Until the fall of 2004, no instances of stress corrosion cracking (SCC) affecting the tubesheet region of thermally treated Alloy 600 tubing had been reported at any nuclear power plants in the United States.

In the fall of 2004, crack-like indications were found in tubes in the tubesheet region of Catawba Unit 2. These crack-like indications were found in a tube overexpansion that was approximately 7-inches below the top of the tubesheet (hot leg side) in one tube, and just above the

tube-to-tubesheet (T/TS) weld in a region of the tube known as the tack expansion region in several other tubes. Indications were also reported near the T/TS welds, which join the tube to the tubesheet. An overexpansion is created when the tube is expanded into a tubesheet bore hole that is not perfectly round. These out-of-round conditions were created during the tubesheet drilling process by conditions such as drill bit wandering or chip gouging. The tack expansion is an approximately 1-inch long expansion at each tube end. The purpose of the tack expansion is to facilitate performing the T/TS weld, which is made prior to the hydraulic expansion of the tube over the full tubesheet depth.

Since the initial findings at Catawba Unit 2 in the fall of 2004, other nuclear plants with Alloy 600TT tubing have found crack-like indications in tubes within the tubesheet as well. Most of the indications were found in the tack expansion region near the tube-end welds and were a mixture of axial and circumferential primary water SCC.

Over time, these cracks can be expected to become more and more extensive, necessitating more extensive inspections of the lower tubesheet region and more extensive tube plugging or repairs, with attendant increased cost and the potential for shortening the useful lifetime of the SGs. To avoid these impacts, the affected licensees and their contractor, Westinghouse Electric Company, LLC, have developed proposed alternative inspection and repair criteria applicable to the tubes in the lowermost region of the tubesheets. These criteria are referred to as the "H\*" criteria. H\* is the minimum engagement distance between the tube and tubesheet, measured downward from the top of the tubesheet, that is proposed as needed to ensure the structural and leakage integrity of the T/TS joints. The proposed H\* proposal would exclude the portions of tubing below the H\* distance from inspection and plugging requirements on the basis that flaws below the H\* distance are not detrimental to the structural and leakage integrity of the T/TS joints.

Requests for permanent H\* amendments were proposed for a number of plants as early as 2005, including TPN Units 3 and 4 in 2006 (Reference 4). The NRC staff identified a number of issues with these early proposals and in subsequent proposals made in 2009, including for TPN Units 3 and 4 (Reference 5), and was unable to approve H\* amendments on a permanent basis pending resolution of these issues. The NRC staff found it did have a sufficient basis to approve H\* amendments on an interim (temporary) basis, based on the relatively limited extent of cracking existing in the lower tubesheet region at the time the interim amendments were approved. The technical basis for approving the interim amendments is provided in detail in the NRC staff's safety evaluations accompanying issuance of these amendments. Interim H\* amendments for TPN Units 3 and 4 were approved in 2006 (Reference 6) and revised interim amendments were approved in 2009 (Reference 7).

## 2.0 REGULATORY EVALUATION

The SG tubes are part of the reactor coolant pressure boundary (RCPB) and isolate fission products in the primary coolant from the secondary coolant and the environment. For the purposes of this safety evaluation, SG tube integrity means that the tubes are capable of performing this safety function in accordance with the plant design and licensing basis.

The General Design Criteria (GDC) in Appendix A to Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50 provide regulatory requirements in the GDC, which state that the RCPB shall

have “an extremely low probability of abnormal leakage and of gross rupture” (GDC 14), “shall be designed with sufficient margin” (GDC 15 and 31), shall be of “the highest quality standards practical” (GDC 30), and shall be designed to permit “periodic inspection and testing...to assess...structural and integrity” (GDC 32). TPN Units 3 and 4 received construction permits prior to May 21, 1971, which is the date the GDC in Appendix A of 10 CFR Part 50 became effective. Although the plant is exempt from the current GDC, the licensee states it is in compliance with the 1967 GDC that were in effect when Turkey Point was licensed, and discusses how it meets each of these GDC for Turkey Point in Section 4.1 of the Updated Final Safety Analysis Report (UFSAR). A review of the 1967 GDC shows that the GDC applicable to the RCPB and SG are comparable to the requirements of the current GDC.

Part 50 of 10 CFR, Section 50.55a specifies that components which are part of the RCPB must meet the requirements for Class 1 components in Section III of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), except as provided in 10 CFR 50.55a(c)(2), (3), and (4). Section 50.55a further requires that throughout the service life of pressurized-water reactor (PWR) facilities like Turkey Points Units 3 and 4, ASME Code Class 1 components meet the Section XI requirements of the ASME Code to the extent practical, except for design and access provisions, and pre-service examination requirements. This requirement includes the inspection and repair criteria of Section XI of the ASME Code. The Section XI requirements pertaining to inservice inspection of SG tubing are augmented by additional requirements in the TSs.

In 10 CFR 50.36, “Technical specifications,” the requirements related to the content of the TSs are established. Pursuant to 10 CFR 50.36, TSs are required to include items in the following five categories: (1) safety limits, limiting safety system settings, and limiting control settings; (2) limiting conditions for operation; (3) surveillance requirements; (4) design features; and (5) administrative controls.

In 10 CFR 50.36(c)(5), “Administrative controls” are, “the provisions relating to organization and management, procedures, recordkeeping, review and audit, and reporting necessary to assure the operation of the facility in a safe manner.” Programs established by the licensee, including the SG program, are listed in the administrative controls section of the TSs to operate the facility in a safe manner. For TPN Units 3 and 4, the requirements for performing SG tube inspections and repair are in TS 6.8.4.j, while the requirements for reporting the SG tube inspections and repair are in TS 6.9.1.8.

The TS for all PWR plants require that an SG program be established and implemented to ensure that SG tube integrity is maintained. For TPN Units 3 and 4, SG tube integrity is maintained by meeting the performance criteria specified in TS 6.8.4.j.b for structural and leakage integrity, consistent with the plant design and licensing basis. Technical specification 6.8.4.j.a requires that a condition monitoring assessment be performed during each outage in which the SG tubes are inspected, to confirm that the performance criteria are being met. Technical specification 6.8.4.j.d includes provisions regarding the scope, frequency, and methods of SG tube inspections. These provisions require that the inspections be performed with the objective of detecting flaws of any type that may be present along the length of a tube and that may satisfy the applicable tube repair criteria. The applicable tube repair criteria, specified in TS 6.8.4.j.c, are that tubes found during inservice inspection to contain flaws with a depth equal to or exceeding 40 percent of the nominal wall thickness shall be

plugged, unless the tubes are permitted to remain in service through application of alternate repair criteria provided in TS 6.8.4.j.c.1, such as is being proposed for TPN Units 3 and 4. The use of the proposed alternate repair criteria does not impact the integrity of the SG tubes and, therefore, the SG tubes still meet the design requirements and the requirements for Class 1 components in Section III of the ASME Code.

The plant TS 3.4.6.2 also includes a limit on operational primary-to-secondary leakage (150 gallons per day), beyond which the plant must be promptly shutdown. Should a flaw exceeding the tube repair limit not be detected during the periodic tube surveillance required by the plant technical specifications, the operational leakage limit provides added assurance of timely plant shutdown before tube structural and leakage integrity, consistent with the design and licensing bases, are impaired.

As part of the plant's licensing bases, applicants for PWR licenses are required to analyze the consequences of postulated design-basis accidents (DBA), such as a SG tube rupture and a main steamline break (MSLB). These analyses consider primary-to-secondary leakage that may occur during these events and must show that the offsite radiological consequences do not exceed the applicable limits of the 10 CFR Part 50.67 or 10 CFR Part 100 for offsite doses, GDC 19 for control room operator doses (or some fraction thereof as appropriate to the accident), or the NRC-approved licensing basis (e.g., a small fraction of these limits).

No accident analyses for TPN Units 3 and 4 are being changed because of the proposed amendment and, thus, no radiological consequences of any accident analysis are being changed. The proposed changes maintain the accident analyses and consequences that the NRC has reviewed and approved for the postulated DBAs for SG tubes.

### 3.0 TECHNICAL EVALUATION

License Amendment No. 241 for TPN Unit 3 and license Amendment No. 236 for TPN 4 (Reference 7, issued on October 30, 2009) modified TS 6.8.4.j, "Steam Generator (SG) Program," and TS 6.9.1.8, "Steam Generator Tube Inspection Report," incorporating interim alternate repair criteria and associated tube inspection and reporting requirements. These interim amendments were applicable to TPN Unit 3 through Refueling Outage 25 (fall 2010) and the subsequent operating cycle and to TPN Unit 4 during Refueling Outage 25 (fall 2009) and the subsequent operating cycles to the next scheduled inspection. The proposed permanent amendments are similar to these interim amendments, with the exception that the proposed H\* distance would be increased slightly (to 18.11 inches) compared to the value in the interim amendments (17.28 inches). The NRC staff recently approved similar permanent H\* amendments for Catawba Unit 2 in March 2012 (Reference 8) and Surry Units 1 and 2 (Reference 9).

#### 3.1 Proposed Changes to the TS

The datum for the indicated changes below are the current TSs, including the currently approved interim alternate repair criteria and associated tube inspection and reporting requirements. The proposed changes are shown in markup form for clarity.



TS 6.8.4.j.c. would be changed as follows:

- c. Provisions for SG tube repair criteria. Tubes found by inservice inspection to contain flaws with a depth equal to or exceeding 40 percent of the nominal tube wall thickness shall be plugged.

The following alternate tube repair criteria shall be applied as an alternative to the 40 percent depth-based criteria:

- a. ~~For Unit 3 through Refueling Outage 25 and the next operating cycle, and for Unit 4 during Refueling Outage 25 and the subsequent operating cycles until the next scheduled inspection, tubes~~ **Tubes** with service-induced flaws located greater than ~~47.28~~ **18.11** inches below the top of the tubesheet do not require plugging. Tubes with service-induced flaws located in the portion of the tube from the top of the tubesheet to ~~47.28~~ **18.11** inches below the top of the tubesheet shall be plugged upon detection.

TS 6.8.4.j.d. would be revised as follows:

- d. Provisions for SG tube inspections. Periodic SG tube inspections shall be performed. The number and portions of the tubes inspected and methods of inspection shall be performed with the objective of detecting flaws of any type (e.g., volumetric flaws, axial and circumferential cracks) that may be present along the length of the tube, from the tube-to-tubesheet weld at the tube inlet to the tube-to-tubesheet weld at the tube outlet, and that may satisfy the applicable tube repair criteria. ~~For Unit 3 through Refueling Outage 25 and the next operating cycle, and for Unit 4 during Refueling Outage 25 and the subsequent operating cycles until the next scheduled inspection, the~~ **The** portion of the tube below ~~47.28~~ **18.11** inches from the top of the tubesheet is excluded from this requirement. The tube-to-tubesheet weld is not part of the tube. In addition to meeting the requirements of d.1, d.2, and d.3 below, the inspection scope, inspection methods, and inspection intervals shall be such as to ensure that SG tube integrity is maintained until the next SG inspection. An assessment of degradation shall be performed to determine the type and location of flaws to which the tubes may be susceptible and, based on this assessment, to determine which inspection methods need to be employed and at what locations.
  - 1. [No change/Not shown]
  - 2. [No change/Not shown]
  - 3. [No change/Not shown]

TS 6.9.1.8 would be revised as follows:

A report shall be submitted within 180 days after the initial entry into MODE 4 following completion of an inspection performed in accordance with the Specification 6.8.4.j,

“Steam Generator (SG) Program.” The report shall include:

a. - h. [No change/Not shown]

~~Note: Report items i, j, and k are applicable following completion of inspections performed through Refueling Outage 25 at Unit 3 (and any inspection performed in the next operating cycle) and Refueling Outage 25 at Unit 4 (and any inspections performed in the subsequent operating cycles until the next scheduled inspection).~~

- i. The primary to secondary leakage rate observed in each SG (if it is not practical to assign the leakage to an individual SG, the entire primary to secondary leakage should be conservatively assumed to be from one SG) during the cycle preceding the inspection which is the subject of the report;
- j. The calculated accident induced leakage rate from the portion of the tubes below ~~47.28~~ **18.11** inches from the top of the tubesheet for the most limiting accident in the most limiting SG. In addition, if the calculated accident induced leakage rate from the most limiting accident is less than 1.82 times the maximum operational primary to secondary leakage rate, the report should describe how it was determined, and
- k. The results of monitoring for tube axial displacement (slippage). If slippage is discovered, the implications of the discovery and corrective action shall be provided.

### 3.2 Technical Evaluation

The T/TS joints are part of the pressure boundary between the primary and secondary systems. Each T/TS joint consists of the tube, which is hydraulically expanded against the bore of the tubesheet, the T/TS weld located at the tube end, and the tubesheet. The joints were designed in accordance with the ASME Code; Section III, as welded joints, not as friction joints. The T/TS welds were designed to transmit the tube end cap pressure loads, during normal operating and DBA conditions, from the tubes to the tubesheet with no credit taken for the friction developed between the hydraulically expanded tube and the tubesheet. In addition, the welds serve to make the joints leak tight.

This design basis is a conservative representation of how the T/TS joints actually work, since it conservatively ignores the role of friction between the tube and tubesheet in reacting the tube end cap loads. The initial hydraulic expansion of the tubes against the tubesheet produces an “interference fit” between the tubes and the tubesheet; thus, producing a residual contact pressure between the tubes and tubesheet, which acts normally to the outer surface of the tubes and the inner surface of the tubesheet bore holes. Additional contact pressure between the tubes and tubesheet is induced by operational conditions as will be discussed in detail below. The amount of friction force that can be developed between the outer tube surface and the inner surface of the tubesheet bore is a direct function of the contact pressure between the tube and tubesheet times the applicable coefficient of friction.

To support the proposed TS changes, the licensee's contractor, Westinghouse, has defined a parameter called H\* to be that distance below the top of the tubesheet over which sufficient frictional force, with acceptable safety margins, can be developed between each tube and the tubesheet under tube end cap pressure loads associated with normal operating and design basis accident conditions to prevent significant slippage or pullout of the tube from the tubesheet, assuming the tube is fully severed at the H\* distance below the top of the tubesheet. For TPN Units 3 and 4, the proposed H\* distance is 18.11 inches. Given that the frictional force developed in the T/TS joint over the H\* distance is sufficient to resist the tube end cap pressure loads, it is the licensee's and Westinghouse's position that the length of tubing between the H\* distance and the T/TS weld is not needed to resist any portion of the tube end cap pressure loads. Thus, the licensee is proposing to change the TS to not require inspection of the tubes below the H\* distance and to exclude tube flaws located below the H\* distance (including flaws in the T/TS weld) from the application of the TS tube repair criteria. Under these changes, the T/TS joint would now be treated as a friction joint extending from the top of the tubesheet to a distance below the top of the tubesheet equal to H\* for purposes of evaluating the structural and leakage integrity of the joint.

The regulatory standard by which the NRC staff has evaluated the subject license amendment is that the amended TSs should continue to ensure that tube integrity will be maintained, consistent with the current design and licensing basis. This includes maintaining structural safety margins consistent with the structural performance criteria in TS 6.8.4.j.b.1 and the design basis, as is discussed in Section 3.2.1.1 below. In addition, this includes limiting the potential for accident-induced primary-to-secondary leakage to values not exceeding the accident-induced leakage performance criteria in TS 6.8.4.j.b.2, which are consistent with values assumed in the licensing basis accident analyses. Maintaining tube integrity in this manner ensures that the amended TS are in compliance with all applicable regulations. The NRC staff's evaluation of joint structural integrity and accident-induced leakage integrity is discussed in Sections 3.2.1 and 3.2.2 of this safety evaluation, respectively.

### 3.2.1 Joint Structural Integrity

#### 3.2.1.1 Acceptance Criteria

Westinghouse has conducted extensive analyses to establish the necessary H\* distance to resist pullout under normal operating and DBA conditions. The NRC staff finds that pullout is the structural failure mode of interest since the tubes are radially constrained against axial fishmouth rupture by the presence of the tubesheet. The axial force which could produce pullout derives from the pressure end cap loads due to the primary-to-secondary pressure differentials associated with normal operating and DBA conditions. Westinghouse determined the needed H\* distance on the basis of maintaining a factor of three against pullout under normal operating conditions and a factor of 1.4 against pullout under DBA conditions. The NRC staff finds that these are the appropriate safety factors to apply to demonstrate structural integrity. These safety factors are consistent with the safety factors embodied in the structural integrity performance criteria in TS 6.8.4.j.b.1 and with the design basis; namely the stress limit criteria in the ASME Code, Section III.

The above approach equates tube pullout to gross structural failure, which is conservative. Should the pullout load be exceeded, tube slippage would generally be limited by the presence

of adjacent tubes and support structures such that the tube would not be expected to pull out of the tubesheet.

The licensee has committed in Reference 1 to monitor for tube slippage as part of the SG inspection program. Under the proposed license amendment, TS 6.9.1.8.k will require that the results of slippage monitoring be included as part of the 180-day report required by TS 6.9.1.8. TS 6.9.1.8.k will also require that should slippage be discovered, the implications of the discovery and corrective action shall be included in the report. The NRC staff finds that slippage is not expected to occur for the reasons discussed in this safety evaluation. In the unexpected event it should occur, it will be important to understand why it occurred so that the need for corrective action can be evaluated. The NRC staff concludes the commitment to monitor for slippage and the accompanying reporting requirements are acceptable.

### 3.2.1.2 3-D Finite Element Analysis

A detailed 3-D finite element analysis (FEA) of the lower SG assembly (consisting of the lower portion of the SG shell, the tubesheet, the channel head, and the divider plate separating the hot- and cold-leg inlet plenums inside the channel head) was performed to calculate tubesheet displacements due to primary pressure acting on the primary face of the tubesheet and SG channel head, secondary pressure acting on the secondary face of the tubesheet and SG shell, and the temperature distribution throughout the entire lower SG assembly. The calculated tubesheet displacements were used as input to the T/Ts interaction analysis evaluated in Section 3.2.1.3 below.

The tubesheet bore holes were not explicitly modeled. Instead, the tubesheet was modeled as a solid structure with equivalent material property values selected such that the solid model exhibited the same stiffness properties as the actual perforated tubesheet. This is a classical approach for analyzing perforated plates that the NRC staff finds acceptable.

Two versions of the 3-D FEA model were used to support the subject license amendment request, a "reference model" documented in Reference 10 that was submitted to support a previous request for a permanent H\* amendment for TPN Units 3 and 4 (Reference 5) and a "revised model" described in the technical support document (Reference 11) cited in the subject license amendment request (Reference 1). The reference 3-D FEA model was used to provide displacement input to the thick shell T/Ts interaction model described in Section 3.2.1.3.1 below. The revised 3-D FEA model was used to provide displacement input to the square cell T/Ts interaction model described in Section 3.2.3.2 below. The revised 3-D model employs a revised mesh near the plane of symmetry (perpendicular to the divider plate) to be consistent with the geometry of the square cell model such that the displacement output from the 3-D model can be applied directly to the edges of the square cell model.

Some non-U.S. units have experienced cracks in the weld between the divider plate and the stub runner attachment on the bottom of the tubesheet. Should such cracks ultimately cause the divider plate to become disconnected from the tubesheet, tubesheet vertical and radial displacements under operational conditions could be significantly increased relative to those for an intact divider plate weld. Although the industry believes that there is little likelihood that cracks such as those seen abroad could cause a failure of the divider plate weld, the 3-D FEA conservatively considered both the case of an intact divider plate weld and a detached divider

plate weld to ensure a conservative analysis. The case of a detached divider plate weld was found to produce the most limiting  $H^*$  values. In the reference analyses (Reference 10), a factor was applied to the 3-D FEA results to account for a non-functional divider plate, based on earlier sensitivity studies. The revised 3-D FEA model assumes the upper 5 inches of the divider plate to be non-existent. The NRC staff finds this further improves the accuracy of the 3-D FEA for the assumed condition of a nonfunctional divider plate.

### 3.2.1.3 T/TS Interaction Model

#### 3.2.1.3.1 Thick Shell Model

The resistance to tube pullout is the axial friction force developed between the expanded tube and the tubesheet over the  $H^*$  distance. The friction force is a function of the radial contact pressure between the expanded tube and the tubesheet. In the reference analysis (Reference 10), Westinghouse used classical thick-shell equations to model the interaction effects between the tubes and tubesheet under various pressure and temperature conditions for purposes of calculating contact pressure (T/TS interaction model). Calculated displacements from the 3-D FEA of the lower tubesheet assembly (Section 3.2.1.2 above) were applied to the thick shell model as input to account for the increment of tubesheet bore diameter change caused by the primary pressure acting on the primary face of the tubesheet and SG channel head, secondary pressure acting on the secondary face of the tubesheet and SG shell, and the temperature distribution throughout the entire lower SG assembly. However, the tubesheet bore diameter change from the 3-D FEA tended to be non-uniform (eccentric) around the bore circumference. The thick shell equations used in the T/TS interaction model are axisymmetric. Thus, the non-uniform diameter change from the 3-D finite element analyses had to be adjusted to an equivalent uniform value before it could be used as input to the T/TS interaction analysis.

A 2-D plane stress finite element model was used to define a relationship for determining a uniform diameter change that would produce the same change to average T/TS contact pressure as would the actual non-uniform diameter changes from the 3-D finite element analyses.

In Reference 12, Westinghouse identified a difficulty in applying this relationship to Model D5 SGs under MSLB conditions. In reviewing the reasons for this difficulty, the NRC staff developed questions relating to the conservatism of the relationship and whether the tubesheet bore displacement eccentricities are sufficiently limited such as to ensure that T/TS contact is maintained around the entire tube circumference. This concern was applicable to all SG models with Alloy 600TT tubing. In Reference 13, the NRC staff documented a list of questions that would need to be addressed satisfactorily before the NRC staff would be able to approve a permanent  $H^*$  amendment. These questions related to the technical justification for the eccentricity adjustment, the distribution of contact pressure around the tube circumference, and a new model under development by Westinghouse to address the aforementioned issue encountered with the Model D5 SGs.

On June 14 and 15, 2010, the NRC staff conducted an audit at the Westinghouse Waltz Mill Site (Reference 14). The purpose of the audit was to gain a better understanding of the  $H^*$  analysis pertaining to eccentricity, to review draft responses to the NRC staff's questions in Reference 13, and to determine which documents would need to be provided on the docket to

support any future requests for a permanent H\* amendment. Based on the audit, including review of pertinent draft responses to Reference 13, the NRC staff concluded that eccentricity does not appear to be a significant variable affecting either average T/TS contact pressure at a given elevation or calculated values of H\*. The NRC staff found that average contact pressure at a given elevation is primarily a function of average bore diameter change at that elevation associated with the pressure and temperature loading of the tubesheet. Accordingly, the NRC staff concluded that no adjustment of computed average bore diameter change considered in the thick shell model is needed to account for eccentricities computed by the 3-D FEA. The material reviewed during the audit revealed that computed H\* values from the reference analyses continued to be conservative when the eccentricity adjustment factor is not applied.

#### 3.2.1.3.2 Square Cell Model

Documentation for the square cell model (Reference 11) is referenced in the subject amendment request for TPN Units 3 and 4 (Reference 1). The square cell model is a 2-D plane stress FEA model of a single square cell of the tubesheet with a bore hole in the middle and each of the four sides of the cell measuring one tube pitch in length. Displacement boundary conditions are applied at the edges of the cell, based on the displacement data from the revised 3-D FEA model. The model also includes the tube cross-section inside the bore. Displacement compatibility between the tube outer surface and bore inner surface is enforced except at locations where a gap between the tube and bore tries to occur.

This model was originally developed in response to the above-mentioned difficulty encountered when applying the eccentricity adjustment to Model D5 SGs T/TS interaction analysis under MSLB conditions using the thick shell model. Early results with this model indicated significant differences compared to the thick shell model, irrespective of whether the eccentricity adjustment was applied to the thick shell model. The square cell model revealed a fundamental problem with how the results of the 3-D FEA model of the lower SG assembly were being applied to the tubesheet bore surfaces in the thick shell model. As discussed in Section 3.2.1.2 above, the perforated tubesheet is modeled in the 3-D FEA model as a solid plate whose material properties were selected such that the gross stiffness of the solid plate is equivalent to that of a perforated plate under the primary-to-secondary pressure acting across the thickness of the plate. This approach tends to smooth out the distribution of tubesheet displacements as a function of radial and circumferential location in the tubesheet, and ignores local variations of the displacements at the actual bore locations. These smoothed out displacements from the 3-D FEA results were the displacements applied to the bore surface locations in the thick shell model. The square cell model provides a means for post-processing the 3-D FEA results such as to account for localized variations of tubesheet displacement at the bore locations as part of T/TS interaction analysis. Based on these findings, square cell models were developed for each of the SG model types including the Model 44F SGs at TPN Units 3 and 4.

The square cell model is applied to nine different elevations, from the top to the bottom of the tubesheet, for each tube and loading case analyzed. The square cell slices at each elevation are assumed to act independently of one another. T/TS contact pressure results from each of the nine slices are used to define the contact pressure distribution from the top to the bottom of the tubesheet.

The resisting force to the applied end cap load, which is developed over each incremental axial distance from the top of the tubesheet, is the average contact pressure over that incremental distance times the tubesheet bore surface area (equal to the tube outer diameter surface area) over the incremental axial distance times the coefficient of friction. The NRC staff reviewed the coefficient of friction used in the analysis and judges it to be a reasonable lower bound (conservative) estimate. The  $H^*$  distance for each tube was determined by integrating the incremental friction forces from the top of the tubesheet to the distance below the top of the tubesheet where the friction force integral equaled the applied end cap load times the appropriate safety factor as discussed in Section 3.2.1.1.

The square cell model assumes as an initial condition that each tube is fully expanded against the tubesheet bore such that the outer tube surface is in contact with the inner surface of the tubesheet bore under room temperature, atmospheric pressure conditions, with zero residual contact pressure associated with the hydraulic expansion process. The NRC staff finds the assumption of zero residual contact pressure in all tubes to be a conservative assumption.

The limiting tube locations in terms of  $H^*$  were determined during the reference analysis to lie along the plane of symmetry perpendicular to the divider plate. The outer edges of the square cell model conform to the revised mesh pattern along this plane of symmetry in the 3-D FEA model of the lower SG assembly, as discussed in Section 3.2.1.2. Because the tubesheet bore holes were not explicitly modeled in the 3-D FEA, only the average displacements along each side of the square cell are known from the 3-D FEA. Three different assumptions for applying displacement boundary conditions to the edges of the square cell model were considered to allow for a range of possibilities about how local displacements might vary along the length of each side. The most conservative assumption, in terms of maximizing the calculated  $H^*$  distance, was to apply the average transverse displacement uniformly over the length of each edge of the square cell.

Primary pressure acting on the inside tube surface and crevice pressure<sup>1</sup> acting on both the tube outside surface and tubesheet bore surface are not modeled directly as in the case of the thick shell model. Instead, the primary side (inside) of the tube is assumed to have a pressure equal to the primary pressure minus the crevice pressure. Note the crevice pressure varies as a function of the elevation being analyzed, as discussed in Section 3.2.1.4.

The NRC staff concludes that the square cell model provides for improved compatibility between the 3-D FEA model of the lower SG assembly and the T/Ts interaction model, more realistic and accurate treatment of the T/Ts joint geometry, and added conservatism relative to the thick shell model used in the reference analyses.

#### 3.2.1.4 Crevice Pressure Evaluation

The  $H^*$  analyses postulate that interstitial spaces exist between the hydraulically expanded tubes and tubesheet bore surfaces. These interstitial spaces are assumed to act as crevices between the tubes and the tubesheet bore surfaces. The NRC staff finds that the assumption of

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<sup>1</sup> Although the tubes are in tight contact with the tubesheet bore surfaces, surface roughness effects are conservatively assumed to create interstitial spaces, which are effectively crevices, between these surfaces. See Section 3.3.1.4 for more information.

crevices is conservative since the pressure inside the crevices acts to push against both the tube and the tubesheet bore surfaces, thus reducing contact pressure between the tubes and tubesheet.

For tubes that do not contain through-wall flaws within the thickness of the tubesheet, the pressure inside the crevice is assumed to be equal to the secondary system pressure. For tubes that contain through-wall flaws within the thickness of the tubesheet, a leak path is assumed to exist, from the primary coolant inside the tube, through the flaw, and up the crevice to the secondary system. Hydraulic tests were performed on several tube specimens that were hydraulically expanded against tubesheet collar specimens to evaluate the distribution of the crevice pressure from a location where through-wall holes had been drilled into the tubes to the top of the crevice location. The T/TS collar specimens were instrumented at several axial locations to permit direct measurement of the crevice pressures. Tests were run for both normal operating and MSLB pressure and temperature conditions.

The NRC staff finds that the use of the drilled holes, rather than through-wall cracks, is conservative since it eliminates any pressure drop between the inside of the tube and the crevice at the whole location. This maximizes the pressure in the crevice at all elevations, thus reducing contact pressure between the tubes and tubesheet.

The crevice pressure data from these tests were used to develop a crevice pressure distribution as a function of normalized distance between the top of the tubesheet and the  $H^*$  distance below the top of the tubesheet where the tube is assumed to be severed. These distributions were used to determine the appropriate crevice pressure at each axial location of the T/TS interaction model and are concluded to be acceptable for this purpose by the NRC staff.

Because the crevice pressure distribution is assumed to extend from the  $H^*$  location, where crevice pressure is assumed to equal primary pressure, to the top of the tubesheet, where crevice pressure equals secondary pressure, an initial guess as to the  $H^*$  location must be made before solving for  $H^*$  using the T/TS interaction model and 3-D finite element model. The resulting new  $H^*$  estimate becomes the initial estimate for the next  $H^*$  iteration.

#### 3.2.1.5 $H^*$ Calculation Process

The calculation of  $H^*$  consists of the following steps for each loading case considered:

1. Perform initial  $H^*$  estimate (mean  $H^*$  estimate) using the T/TS interaction model and 3-D FEA models, assuming nominal geometric and material properties, and assuming that the tube is severed at the bottom of the tubesheet for purposes of defining the contact pressure distribution over the length of the T/TS crevice. Two sets of mean  $H^*$  estimates are pertinent to the proposed  $H^*$  value, mean  $H^*$  estimates calculated with the reference T/TS interaction and 3-D FEA models and mean  $H^*$  estimates calculated with the square cell T/TS interaction and revised 3-D FEA models. The maximum, mean  $H^*$  estimate (for the most limiting tube) from the reference analysis is 3.87 inches, for the most limiting case of normal operating conditions (with the associated factor of safety of 3 as evaluated in Section 3.2.1.1). This estimate includes the adjustment in Item 2 below. The maximum, mean  $H^*$  estimate with the square cell model in



conjunction with the revised 3-D lower SG FEA model is 7.88 inches. Again, the most limiting loading case for this revised analysis is normal operating conditions. The NRC staff finds that the difference in mean  $H^*$  estimates between the reference analysis and the revised analysis is dominantly due to the improved post-processing of the 3-D FEA model displacements for application to the T/Ts interaction model.

2. In the reference analysis (Reference 10), a 0.3-inch adjustment was added to the initial  $H^*$  estimate to account for uncertainty in the bottom of the tube expansion transition (BET) location relative to the top of the tubesheet, based on an uncertainty analysis on the BET for Model F SGs conducted by Westinghouse. This adjustment is not included in the revised  $H^*$  analysis accompanying the subject amendment request amendment, as discussed and evaluated in Section 3.2.1.5.1 of this safety evaluation.
3. Steps 1 through 2 yield a so-called "mean" estimate of  $H^*$ , which is deterministically based. Step 3 involves a probabilistic analysis of the potential variability of  $H^*$ , relative to the mean estimate, associated with the potential variability of key input parameters for the  $H^*$  analyses. This leads to a "probabilistic" estimate of  $H^*$ , which includes the mean estimate. The NRC staff's evaluation of the probabilistic analysis is provided in Sections 3.2.1.6 and 3.2.1.7 of this safety evaluation.
4. Add a crevice pressure adjustment to the probabilistic estimate of  $H^*$  to account for the crevice pressure distribution which results from the tube being severed at the final  $H^*$  value, rather than at the bottom of the tubesheet. This step is discussed and evaluated in Section 3.2.1.5.2 of this safety evaluation.
5. A new step, step 6, has been added to the  $H^*$  calculation process since the reference analysis to support the subject amendment request. This step involves adding an additional adjustment to the probabilistic estimate of  $H^*$  to account for the Poisson contraction of the tube radius due to the axial end cap load acting on each tube.

This step is discussed and evaluated in Section 3.2.1.5.3 of this safety evaluation.

#### 3.2.1.5.1 BET Considerations

The diameter of each tube transitions from its fully expanded value to its unexpanded value near the top of the tubesheet (TTS). The BET region is located a short distance below the top of tubesheet so as to avoid any potential for over-expanding the tube above the TTS. In the reference  $H^*$  analysis (Reference 10), a 0.3-inch adjustment was added to the mean  $H^*$  estimate to account for the BET location being below the TTS based on an earlier survey of BET distances conducted by Westinghouse. This adjustment was necessary since the reference analysis did not explicitly account for the lack of contact between the tube and tubesheet over the BET distance.

BET measurements, based on eddy current testing, have subsequently been performed for all tubes at TPN Units 3 and 4. These measurements revealed upper 95 percent BET values in each SG at both units ranging to a maximum of 0.28 inches. All tubes with BET values exceeding 1 inch were plugged, including nine tubes with incomplete expansions.

The most recent H\* analyses using the square cell T/Ts interaction model (Reference 11) has made the need for a BET adjustment unnecessary, as the square cell Model shows a loss of contact pressure over a distance from the TTS that is greater than the possible variation in the BET location. This observation applies to all radial locations for probabilistic values of tube and tubesheet coefficients of thermal expansion associated with limiting probabilistic H\* values. The NRC staff concludes that the proposed H\* value adequately accounts for the range of BET values at TPN Units 2 and 3.

#### 3.2.1.5.2 Crevice Pressure Adjustment

As discussed in Section 3.2.1.5, steps 1 through 3 of the H\* calculation process leading to a probabilistic H\* estimate are performed with the assumption that the tube is severed at the bottom of the tubesheet for purposes of calculating the distribution of crevice pressure as a function of elevation. If the tube is assumed to be severed at the initially computed H\* distance and steps 1 through 3 are repeated, a new H\* may be calculated that will be incrementally larger than the first estimate. This process may be repeated until the change in H\* becomes small (convergence). Sensitivity analyses conducted with the thick shell model showed that the delta between the initial H\* estimate and final (converged) estimate is a function of the initial estimate for the tube in question. This delta (i.e., the crevice pressure adjustment referred to in step 4 of Section 3.2.1.5) was plotted as a function of the initial H\* estimate for the limiting loading case and tube radial location. Although the sensitivity study was conducted with the thick shell model, the deltas from this study were used in the Reference 11 (square cell model) analysis to make the crevice pressure adjustment to H\*. Updating this sensitivity study would have been very resource intensive, requiring many new 2-D FEA square cell runs. In response to an NRC staff question as to whether it is conservative to rely on the existing sensitivity study as opposed to updating it to reflect the square cell model, Westinghouse submitted an analysis on the Surry docket (Reference 15) demonstrating that if the sensitivity study were updated, it would show that the crevice pressure adjustment H\* is negative for Model 44F and 51F SGs, not positive as is shown by the existing study with the thick shell model. This is because the square cell model predicts a much longer zone of no T/Ts contact below the top of the tubesheet than does the thick shell model. Therefore, the crevice pressure must reduce from primary side pressure at the iterative H\* location to secondary side pressure several inches below the top of the tubesheet. This leads to higher predicted pressure differentials across the tube wall over the iterative H\* distance than exists during the initial iteration when crevice pressure is initially assumed to vary from primary pressure at the very bottom of the tubesheet to secondary pressure at the very top of the tubesheet. Based on its review of the Westinghouse analysis, the NRC staff concludes that the positive crevice pressure adjustment to H\* in the Reference 10 analysis, which is based on the existing sensitivity study, is conservative and that an updated sensitivity analysis based on use of the square cell model would show that a negative adjustment can actually be justified. Thus, the NRC staff concludes the crevice pressure adjustment performed in support of the proposed H\* amendment is conservative and acceptable.

### 3.2.1.5.3 Poisson Contraction Effect

The axial end cap load acting on each tube is equal to the primary-to-secondary pressure difference times the tube cross-sectional area. For purposes of resisting tube pullout under normal and accident conditions, the end cap loads used in the H\* analyses are based on the tubesheet bore diameter, which the NRC staff finds to be a conservative assumption. The axial end cap load tends to stretch the tube in the axial direction, but causes a slight contraction in the tube radius due to the Poisson's Ratio effect. This effect, by itself, tends to reduce the T/TS contact pressure and, thus, to increase the H\* distance. The axial end cap force is resisted by the axial friction force developed at the T/TS joint. Thus, the axial end cap force begins to decrease with increasing distance into the tubesheet, reaching zero at a location before the H\* distance is reached. This is because the H\* distances are intended to resist pullout under the end cap loads with the appropriate factors of safety applied as discussed in Section 3.2.1.1.

A simplified approach was taken to account for the Poisson radial contraction effect. First, thick shell equations were used to estimate the reduction in contact pressure associated with application of the full end cap load, assuming none of this end cap load has been reacted by the tubesheet. The T/TS contact pressure distributions determined in Step 3 of the H\* calculation process in Section 3.2.1.5 were reduced by this amount. Second, the friction force associated with these reduced T/TS contact pressures were integrated with distance into the tubesheet, and the length of engagement necessary to react one times the end cap loading (i.e., no safety factor applied) was determined. At this distance (termed attenuation distance by Westinghouse), the entire end cap loading was assumed to have been reacted by the tubesheet, and the axial load in the tube below the attenuation distance was assumed to be zero. Thus, the T/TS contact pressures below the attenuation distance were assumed to be unaffected by the Poisson radial contraction effect. Finally, a revised H\* distance was calculated, where the T/TS contact pressures from Step 3 of Section 3.2.1.5 were reduced only over the attenuation distance.

The NRC staff finds the simplified approach for calculating the H\* adjustment for the Poisson contraction effect to contain significant conservatism relative to a more detailed approach. The NRC staff concludes there is ample conservatism embodied in the proposed H\* distance to accommodate the difference. This finding is made without regard to the application of a safety factor to the Poisson's contraction effect (consistent with Section 3.2.1.1 above).

### 3.2.1.6 Acceptance Standard - Probabilistic Analysis

The purpose of the probabilistic analysis is to develop an H\* distance that ensures with a probability of 0.95 that the population of tubes will retain margins against pullout consistent with criteria evaluated in Section 3.2.1.1 of this safety evaluation, assuming all tubes to be completely severed at their H\* distance. The NRC staff finds this probabilistic acceptance standard is consistent with what the NRC staff has approved previously and is acceptable. For example, the upper voltage limit for the voltage based tube repair criteria in NRC Generic Letter 95-05 (Reference 16) employs a consistent criterion. The NRC staff also notes that use of the 0.95 probability criterion ensures that the probability of pullout of one or more tubes under normal operating conditions and conditional probability of pullout under accident conditions is well within tube rupture probabilities that have been considered in probabilistic risk assessments (References 17 and 18).

In terms of the confidence level that should be attached to the 0.95 probability acceptance standard, it is industry practice for SG tube integrity evaluations, as embodied in industry guidelines, to calculate such probabilities at a 50 percent confidence level. The NRC staff has been encouraging the industry to revise its guidelines to call for calculating such probabilities at a 95 percent confidence level when performing operational assessments and a 50 percent confidence level when performing condition monitoring (Reference 19). In the meantime, the calculated H\* distances supporting the amendment currently being requested have been evaluated at the 95 percent confidence level, as recommended by the NRC staff.

Another issue relating to the acceptance standard for the probabilistic analysis is determining what population of tubes needs to be analyzed. For accidents such as MSLB or feed line break, the NRC staff and licensee each find that the tube population in the faulted SG is of interest, since it is the only SG that experiences a large increase in the primary-to-secondary pressure differential. However, normal operating conditions were found to be the most limiting in terms of meeting the tube pullout margins in Section 3.2.1.1. For normal operating conditions, tubes in all SGs at the plant are subject to the same pressures and temperatures. Although there is not a consensus between the NRC staff and industry on which population needs to be considered in the probabilistic analysis for normal operating conditions, the calculated H\* distances for normal operating conditions supporting the requested interim amendment are 0.95 probability/95 percent confidence estimates based on the entire tube population for the plant, consistent with the NRC staff's recommendation.

Based on the above, the NRC staff concludes that the proposed H\* distance in the subject license amendment request is based on acceptable probabilistic acceptance standards evaluated at acceptable confidence levels.

### 3.2.1.7 Probabilistic Analyses

#### 3.2.1.7.1 Reference Analyses

Sensitivity studies were conducted during the reference analyses (Reference 10) and demonstrated that H\* was highly sensitive to the potential variability of the coefficients of thermal expansion (CTE) for the Alloy 600 tubing material and the SA-508 Class 2a tubesheet material. Given that no credit was taken in the reference H\* analyses (Reference 10) for residual contact pressure associated with the tube hydraulic expansion process,<sup>2</sup> the sensitivity of H\* to other geometry and material input parameters was judged by Westinghouse to be inconsequential and were ignored, with the exception of Young's modulus of elasticity for the tube and tubesheet materials. Although the Young's modulus parameters were included in the reference H\* analyses sensitivity studies, these parameters were found to have a weak effect on the computed H\*. Based on its review of the analysis models and its engineering judgment, the NRC staff finds that the sensitivity studies adequately capture the input parameters which may significantly affect the value of H\*. This conclusion is based, in part, on no credit being taken for residual contact pressure during the reference H\* analyses.

These sensitivity studies were used to develop influence curves describing the change in H\* ,

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<sup>2</sup> Residual contact pressures are sensitive to variability of other input parameters.

relative to the mean  $H^*$  value estimate (Section 3.2.1.5), as a function of the variability of each CTE parameter and Young's modulus parameter, relative to the mean values of CTE and Young's Modulus. Separate influence curves were developed for each of the four input parameters. The sensitivity studies showed that of the four input parameters, only the CTE parameters for the tube and tubesheet material had any interaction with one another. A combined set of influence curves containing this interaction effect were also created.

Two types of probabilistic analyses were performed independently in the reference analyses. One was a simplified statistical approach utilizing a "square root of the sum of the squares" method and the other was a detailed Monte Carlo sampling approach. The NRC staff's review of the reference analysis relied on the Monte Carlo analysis, which provides the most realistic treatment of uncertainties. The NRC staff reviewed the implementation of probabilistic analyses in the reference analyses and questioned whether the  $H^*$  influence curves had been conservatively treated. To address this concern, new  $H^*$  analyses were performed as documented in References 20 and 21. These analyses made direct use of the  $H^*$  influence curves in a manner the NRC staff finds to be acceptable.

The revised reference analyses in Reference 21 divided the tubes by sector location within the tube bundle and all tubes were assumed to be at the location in their respective sectors where the initial value of  $H^*$  (based on nominal values of material and geometric input parameters) was at its maximum value for that sector. The  $H^*$  influence curves discussed above, developed for the most limiting tube location in the tube bundle, were conservatively used for all sectors.

The revised reference analyses also addressed a question posed by the NRC staff concerning the appropriate way to sample material properties for the tubesheet, whose properties are unknown but do not vary significantly for a given SG, in contrast to the tubes whose properties tend to vary much more randomly from tube to tube in a given SG. This issue was addressed by a staged sampling process where the tubesheet properties were sampled once and then held fixed, while the tube properties were sampled a number of times equal to the SG tube population. This process was repeated 10,000 times, and the maximum  $H^*$  value from each repetition was rank ordered. The final  $H^*$  value was selected from the rank ordering to reflect a 0.95 probability value at the desired level of confidence for a single SG tube population or all SG population, as appropriate. The NRC staff concludes that this approach addresses the NRC staff's question in a realistic fashion and is acceptable.

#### 3.2.1.7.2 Revised Analyses to Reflect Square Cell and Revised 3-D FEA Models

New Monte Carlo analyses using the square cell model to evaluate the statistical variability of  $H^*$  due to the CTE variability for the tube and tubesheet materials were not performed. This was because such an approach would have been extremely resource intensive and because a simpler approach involving good approximation was available. The simplified approach involved using the results of the Monte Carlo analyses from the reference analysis, which are based on the thick shell T/TS interaction model, to identify CTE values for the tube and tubesheet associated with the probabilistic  $H^*$  values near the desired rank ordering. Tube CTE values associated with the upper 10 percent rank order estimates are generally negative variations from the mean value whereas tubesheet CTE values associated with the higher ranking order estimates are generally positive variations from the mean value. For the upper 10 percent of the Monte Carlo results ranking order, a combined uncertainty parameter,

“alpha,” was defined as the square root of the sum of the squares of the associated tube and tubesheet CTE values for each Monte Carlo sample. Alpha was plotted as a function of the corresponding H\* estimate and separately as a function of rank order. Each of these plots exhibited well defined “break lines,” representing the locus of maximum H\* estimates and maximum rank orders associated with a given values of alpha. From these plots, three paired sets of tube and tubesheet CTE values, located near the break line, were selected. These CTE values were then input to the lower SG assembly 3-D FEA model and the square cell model to yield probabilistic H\* estimates which approximate the H\* values for these same rank orderings had a full Monte Carlo been performed with the square cell and revised 3-D FEA models. These H\* estimates were then plotted as a function of rank ordering, allowing the interpolation of H\* values at the other rank orders. The resulting 95/95 upper bound H\* estimate is 15.75 inches, which compares to the mean estimate of 7.88 inches as discussed in Section 3.2.1.5. With adjustments for Poisson's contraction (see Section 3.2.1.5.3) and crevice pressure (Section 3.2.1.5.2), the final 95/95 upper bound H\* estimate is 18.11 inches, which is the value in the subject amendment request.

The NRC staff considers that the above break line approach to be a very good approximation of what an actual Monte Carlo would show. A perfect approximation would mean that if hypothetically one were to perform a square cell analysis for each paired set of tube and tubesheet CTE values associated with the top 10 percent of rank orders and plot the resulting H\* values versus the original rank ordering associated with the CTE couple, the calculated H\* values should monotonically increase from rank order to rank order. Westinghouse performed additional square cell analyses with CTE pairs for five consecutive rank orders for both Model D5 and Model F SGs. The results showed deviations from monotonically increasing values of H\* with rank order to be on the order of only 0.3 inches for the Model D5 SGs and 0.1 inches for the Model F SGs. The NRC staff considers these deviations to be representative for the Model 44F SGs at TPN Units 3 and 4. The NRC staff concludes that use of the break line approach adds little imprecision to the probabilistic H\* estimates and is acceptable.

### 3.2.1.8 Coefficient of Thermal Expansion

During operation, a large part of contact pressure in a SG T/TS joint is derived from the difference in CTE between the tube and tubesheet. As discussed in Section 3.2.1.7, the calculated value of H\* is highly sensitive to the assumed values of these CTE parameters. However, CTE test data acquired by an NRC contractor, Argonne National Laboratory (ANL), suggested that CTE values may vary substantially from values listed in the ASME Code for design purposes. In Reference 22, the NRC staff highlighted the need to develop a rigorous technical basis for the CTE values, and their potential variability, to be employed in future H\* analyses.

In response, Westinghouse had a subcontractor review the CTE data in question, determine the cause of the variance from the ASME Code CTE values, and provide a summary report (Reference 23). Analysis of the CTE data in question revealed that the CTE variation with temperature had been developed using a polynomial fit to the raw data, over the full temperature range from 75 °F to 1300 °F. The polynomial fit chosen resulted in mean CTE values that were significantly different from the ASME Code values from 75 °F to about 300 °F. When the raw data was reanalyzed using the locally weighted least squares regression (LOWESS) method, the mean CTE values determined were in good agreement with the

established ASME Code values.

Westinghouse also formed a panel of licensee experts to review the available CTE data in open literature, review the ANL provided CTE data, and perform an extensive CTE testing program on Alloy 600 and SA-508 steel material to supplement the existing data base. Two additional sets of CTE test data (different from those addressed in the previous paragraph) had CTE offsets at low temperatures that were not expected. Review of the test data showed that the first test, conducted in a vacuum, had proceeded to a maximum temperature of 1300 °F, which changed the microstructure and the CTE of the steel during decreasing temperature conditions. As a result of the altered microstructure, the CTE test data generated in the second test, conducted in air, was also invalidated. As a result of the large "dead band" region and the altered microstructure, both data sets were excluded from the final CTE values obtained from the CTE testing program. The test program included multiple material heats to analyze chemistry influence on CTE values and repeat tests on the same samples were performed to analyze for test apparatus influence. Because the tubes are strain hardened when they are expanded into the tubesheet, strain hardened samples were also measured to check for strain hardening influence on CTE values.

The data from the test program was combined with the ANL data that was found to be acceptable and the data obtained from the open literature search. A statistical analysis of the data uncertainties was performed by comparing deviations to the mean values obtained at the applicable temperatures. The correlation coefficients obtained indicated a good fit to a normal distribution, as expected. Finally, an evaluation of within-heat variability was performed due to increased data scatter at low temperatures. The within-heat variability assessment determined that the increase in data scatter was a testing accuracy limitation that was only present at low temperature. The CTE report is included as Appendix A to Reference 10.

The testing showed that the nominal ASME Code values for Alloy 600 and SA-508 steel were both conservative relative to the mean values from all the available data. Specifically, the CTE mean value for Alloy 600 was greater than the ASME Code value and the CTE mean value for SA-508 steel was smaller than the ASME Code value. Thus, the H\* analyses utilized the ASME Code values as mean values in the H\* analyses. The NRC staff finds this to be conservative because it tends to lead to an over-prediction of the expansion of the tubesheet bore and an under-prediction of the expansion of the tube, thereby resulting in an increase in the calculated H\* distance. The statistical variances of the CTE parameters from the combined data base were utilized in the H\* probabilistic analysis.

Based on its review of the Westinghouse CTE program, the NRC staff concludes that the CTE values used in the H\* analyses are fully responsive to the concerns stated in Reference 22 and are acceptable.

### 3.2.2 Leakage Considerations

Operational leakage integrity is assured by monitoring primary-to-secondary leakage relative to the applicable TS limited condition for operation limits in TS 3.4.6.2, "RCS Operational LEAKAGE." However, it must also be demonstrated that the proposed TS changes do not create the potential for leakage during DBA to exceed the accident leakage performance criteria in TS 6.8.4.j.b.2 which are based on the leakage values assumed in the plant licensing basis accident analyses.

If a tube is assumed to contain a 100 percent through-wall flaw some distance into the tubesheet, a potential leak path between the primary and secondary systems is introduced between the hydraulically expanded tubing and the tubesheet. The leakage path between the tube and tubesheet has been modeled by the licensee's contractor, Westinghouse, as a crevice consisting of a porous media. Using Darcy's model for flow through a porous media, leak rate is proportional to differential pressure and inversely proportional to flow resistance. Flow resistance is a direct function of viscosity, loss coefficient, and crevice length.

Westinghouse performed leak tests of T/TS joint mockups to establish loss coefficient as a function of contact pressure. A large amount of data scatter, however, precluded quantification of such a correlation. In the absence of such a correlation, Westinghouse has developed a leakage factor relationship between accident induced leaks rate and operational leakage rate, where the source of leakage is from flaws located at or below the  $H^*$  distance.

Using the Darcy model, the leakage factor for a given type accident is the product of four quantities. The first quantity is ratio of the maximum primary-to-secondary pressure difference during the accident divided by that for normal operating conditions. The second quantity is the ratio of viscosity under normal operating primary water temperature divided by viscosity under the accident condition primary water temperature. The third quantity is the ratio of crevice length under normal operating conditions to crevice length under accident conditions. This ratio equals 1, provided it can be shown that positive contact pressure is maintained along the entire  $H^*$  distance for both conditions. The fourth quantity is the ratio of loss coefficient under normal operating conditions to loss coefficient under the accident condition. Although the absolute value of these loss coefficients is not known, Westinghouse has assumed that the loss coefficient is constant with contact pressure such that the ratio is equal to 1. The NRC staff finds that this is a conservative assumption, provided there is a positive contact pressure for both conditions along the entire  $H^*$  distance and provided that contact pressure increases at each axial location along the  $H^*$  distance when going from normal operating to accident conditions. Both assumptions were confirmed to be valid in the  $H^*$  analyses.

Leakage factors were calculated for design basis accidents exhibiting a significant increase in primary-to-secondary pressure differential, including MSLB, locked rotor, and control rod ejection. The design basis MSLB transient was found to exhibit the highest leakage factor, 1.82, meaning that it is the transient expected to result in the largest increase in leakage relative to normal operating conditions.

The licensee in its submittal provided a commitment (Section 4 of this SE) that describes how the leakage factor will be used to satisfy TS 5.5.9.a for condition monitoring and TS 5.5.9.b.2 regarding performance criteria for accident induced leakage. That this commitment is not part



of the plant license is consistent with the fact that details of how condition monitoring and operational assessments are performed are generally not included as part of the operating license, including the technical specifications. Extensive industry guidance on conducting condition monitoring and operational assessments is available as part of the industry Nuclear Energy Institute (NEI) 97-06 initiative (Reference 24). The commitments in Section 4 of this SE ensure that plant procedures address the above leakage factor issue as they do industry guidelines.

The subject amendment request would include reporting requirements (TS 6.9.1.8.i and TS 6.9.1.8.j) relating to operational leakage existing during the cycle preceding each SG inspection and condition monitoring assessment, and the associated potential for accident induced leakage from the lower portion of the tubesheet below the H\* distance. These reporting requirements will allow the NRC staff to monitor how the leakage factor is actually being used, and are acceptable.

### 3.3 Summary and Conclusions

Since the initial proposal for a permanent H\* amendment in 2006 (Reference 4), the supporting technical analyses have undergone substantial revision and refinement to address NRC staff questions and issues. The current analyses supporting the proposed permanent amendment still embody uncertainties and issues (e.g., should a factor of safety be applied to the Poisson's contraction effect) as discussed throughout this safety evaluation. However, it is important to acknowledge that there are significant conservatisms in the analyses. Some examples, also discussed elsewhere in this safety evaluation, include taking no credit for residual contact pressures associated with the hydraulic tube expansion process, the assumed value of 0.2 for coefficient of friction between the tube and tubesheet, and taking no credit for constraint against pullout provided by adjacent tubes and support structures. The NRC staff has evaluated the potential impact of the uncertainties and concludes these uncertainties to be adequately bounded by the significant conservatism within the analyses and proposed H\* distance.

The NRC staff finds the proposed changes to the TPN Units 3 and 4 TSs ensure that tube structural and leakage integrity will be maintained with structural safety margins consistent with the design basis and with leakage integrity within assumptions employed in the licensing basis accident analyses, without undue risk to public health and safety. Based on this finding, the NRC staff further concludes that the proposed amendment meets 10 CFR 50.36 and, thus, the proposed amendment is acceptable.

### 4.0 REGULATORY COMMITMENTS

The licensee, in its letter dated October 18, 2012, committed to the following regulatory commitments.

REGULATORY COMMITMENTS		IMPLEMENT
1	Turkey Point Units 3 and 4 commit to monitor for tube slippage as part of the steam generator tube inspection program.	At each scheduled inspection required by the Steam Generator Program (TS 6.8.4.j).
2	<p>Turkey Point Units 3 and 4 commit to the following:</p> <p>Turkey Point Units 3 and 4 will apply a factor of 1.82 to the normal operating leakage associated with the tubesheet expansion region in the condition monitoring (CM) and operational assessment (OA). Specifically, for the CM assessment, the component of operational leakage from the prior cycle from below the H* distance will be multiplied by a factor of 1.82 and added to the total accident leakage from any other source and compared to the allowable accident induced leakage limit. For the OA, the difference between the allowable accident induced leakage and the accident induced leakage from sources other than the tubesheet expansion region will be divided by 1.82 and compared to the observed operational leakage. An administrative limit will be established to not exceed the calculated value.</p>	An administrative operational leakage limit associated with the Permanent Alternate Repair Criteria (PARC) and the 1.82 leakage factor will be established in the CMOA starting with the Unit 4 Cycle 27 RFO and the Unit 3 Cycle 27 RFO.

5.0 STATE CONSULTATION

Based upon a letter dated May 2, 2003, from Michael N. Stephens of the Florida Department of Health, Bureau of Radiation Control, to Brenda L. Mozafari, Senior Project Manager, U.S. Nuclear Regulatory Commission, the State of Florida does not desire notification of issuance of license amendments.

6.0 ENVIRONMENTAL CONSIDERATION

These amendments involve a change in 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 amendments involve 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 amendments involve no significant hazards consideration, and there has been no public comment on such finding (77 FR 47126). Accordingly, these amendments meet 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 amendments.

## 7.0 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) there is reasonable assurance that such activities will be conducted in compliance with the Commission's regulations, and (3) the issuance of the amendments will not be inimical to the common defense and security or to the health and safety of the public.

## 8.0 REFERENCES

1. Florida Power and Light Company (FPL) letter L-2012-077, "Turkey Point Nuclear Generating Station Units 3 and 4 – License Amendment Request No. 220 – Permanent Alternate Repair Criteria (H\*) for Steam Generator Expansion Region," April 30, 2012, NRC ADAMS Accession No. ML12130A206.
2. FPL letter L-2012-373 "Turkey Point Nuclear Generating Station Units 3 and 4 – License Amendment Request No. 220 – Permanent Alternate Repair Criteria (H\*) for Steam Generator Expansion Region," October 10, 2012.
3. FPL letter L-2012-379, "Turkey Point Nuclear Generating Station Units 3 and 4 – License Amendment Request No. 220 – Permanent Alternate Repair Criteria (H\*) for Steam Generator Expansion Region," October 18, 2012.
4. FPL letter L-2006-092, "Turkey Point Units 3 and 4, License Amendment Request for Steam Generator Alternate Repair Criteria for Tube Portion Within the Tubesheet," April 27, 2006, NRC ADAMS Accession No. ML061310089.
5. FPL letter L-2009-151, "License Amendment Request No. 197 for H\*: Alternate Repair Criteria for Steam Generator Tubesheet Expansion Region," July 23, 2009, NRC ADAMS Accession No. ML092300059. This letter also transmitted Reference 8.
6. NRC letter to FPL, "Turkey Point Plant, Units 3 and 4 - Issuance of Amendments Regarding Steam Generator Alternate Repair Criteria," November 1, 2006, NRC ADAMS Accession No. ML062990169.
7. NRC letter to FPL, "Turkey Point Units 3 and 4 - Issuance of Amendments Re. H\*; Alternate Repair Criteria for Steam Generator Tubesheet Expansion Region," October 30, 2009, NRC ADAMS Accession No. ML092990489.
8. NRC letter to Duke Energy Carolinas, LCC, "Catawba Nuclear Station, Units 1 and 2 - Issuance of Amendment Nos. 267 and 263, Revised Technical Specifications for Permanent Alternate Repair Criteria for Steam Generator Tubes," March 12, 2012, NRC ADAMS Accession No. ML12054A692.

9. NRC letter to Virginia Electric and Power Company, "Surry Power Station, Units 1 and 2, Issuance of Amendments Regarding Virginia Electric and Power Company License Amendment Request For Permanent Alternate Repair Criteria For Steam Generator Tube Inspection and Repair," April 17, 2012, NRC ADAMS Accession No. ML12109A270.
10. Westinghouse Electric Company report, WCAP-17091-P (Proprietary) and WCAP-17091-NP (Non-Proprietary), Rev. 0, "H\*: Alternate Repair Criteria for the Tubesheet Expansion Region in Steam Generators with Hydraulically Expanded Tubes (Model 44F)," June 2009, NRC ADAMS Accession No. ML092300060.
11. Westinghouse Electric Company report, WCAP-17345-P (Proprietary) and WCAP-17345-NP (Non-Proprietary), Rev. 2, "H\*: Resolution of NRC Technical Issue Regarding Tubesheet Bore Eccentricity (Three Loop Model 44F/Model 51F)," June 2011; NRC ADAMS Accession Nos. ML11215A060 (Proprietary) and ML11215A059 (Nonproprietary).
12. Westinghouse Electric Company (WEC) report, WCAP-17072-P (Proprietary) and WCAP-17072-NP (Nonproprietary), Rev. 0, "H\*: Alternate Repair Criteria for the Tubesheet Expansion Region in Steam Generators with Hydraulically Expanded Tubes (Model D5)," May 2009, NRC ADAMS Accession Nos. ML101730386 / ML101730393 (Proprietary) and ML101730389 (Nonproprietary).
13. NRC letter to Southern Nuclear Operating Company, "Vogtle Electric Generating Plant, Units 1 and 2, Transmittal of Unresolved Issues Regarding Permanent Alternate Repair Criteria for Steam Generators," November 23, 2009, NRC ADAMS Accession No. ML093030490.
14. NRC memorandum, R. Taylor to G. Kulesa, "Vogtle Electric Generating Plant – Audit of Steam Generator H\* Amendment Reference Documents," July 9, 2010, NRC ADAMS Accession No. ML101900227.
15. Virginia Electric and Power Company, "Surry Power Station Units 1 and 2 – Response to Request for Additional Information Related to License Amendment Request for Permanent Alternate Repair Criteria for Steam Generator Tube Inspection and Repair," February 14, 2012, NRC ADAMS Accession No. ML120480827.
16. NRC Generic Letter 95-05, "Voltage Based Alternate Repair Criteria for Westinghouse Steam Generator Tubes Affected by Outside Diameter Stress Corrosion Cracking," August 3, 1995, NRC ADAMS Accession No. ML031070113.
17. NUREG-0844, "NRC Integrated Program for the Resolution of Unresolved Safety Issues A-3, A-4, and A-5 Regarding Steam Generator Tube Integrity," September 1988.

18. NUREG-1570, "Risk Assessment of Severe Accident-Induced Steam Generator Tube Rupture," March 1998.
19. NRC Meeting minutes, "Summary of the January 8, 2009, Category 2 Public Meeting with the Nuclear Energy Institute (NEI) and Industry to Discuss Steam Generator Issues," February 6, 2009, NRC ADAMS Accession No. ML090370782.
20. WEC letter, LTR-SGMP-09-100-P (Proprietary) and LTR-SGMP-09-100-NP (Nonproprietary) "Response to NRC Request for Additional Information on H\*; Model F and D5 Steam Generators," August 12, 2009, NRC ADAMS Accession No. ML101730397 (Proprietary) and ML101730391 (Nonproprietary).
21. Southern Nuclear Company letter NL-09-1317, August 28, 2009, transmitting WEC letter LTR-SGMP-09-104-P Attachment "White Paper on Probabilistic Assessment of H\*" dated August 13, 2009, NRC ADAMS Accession Nos. ML092450030 (Proprietary) and ML092450029 (Non- Proprietary).
22. NRC letter to Wolf Creek Nuclear Operating Corporation, "Wolf Creek Generating Station – Withdrawal of License Amendment Request on Steam Generator Tube Inspections," February 28, 2008, NRC ADAMS Accession No. ML080450185.
23. NEI letter dated July 7, 2008, NRC ADAMS Accession No. ML082100086, transmitting Babcock and Wilcox Limited Canada letter 2008-06-PK-001, "Re-assessment of PMIC [Precision Measurements and Instruments Cooperation] measurements for the determination of CTE of SA 508 Steel," dated June 6, 2008, NRC ADAMS Accession No. ML082100097.
24. NEI 97-06, Revision 3, "Steam Generator Program Guidelines," January 2011, NRC ADAMS Accession No. ML111310708.

Principal Contributor: Emmett L. Murphy

Date: November 5, 2012

M. Nazar

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

Sincerely,

*/RA/*

Farideh E. Saba, Senior Project Manager  
Plant Licensing Branch II-2  
Division of Operating Reactor Licensing  
Office of Nuclear Reactor Regulation

Docket Nos. 50-250 and 50-251

Enclosures:

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2. Amendment No. 250 to DPR-41
3. Safety Evaluation

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