Florida Power & Light Company, 6501 South Ocean Drive, Jensen Beach, FL 34957

FPL

June 23, 2003

L-2003-163
10 CFR 54

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D.C. 20555

Re: St. Lucie Units 1 and 2
Docket Nos. 50-335 and 50-389
Supplemental Response to Safety Evaluation Report Open Item for Review of the St. Lucie Units 1 and 2 License Renewal Application

By letter dated March 28, 2003 (L-2003-070), Florida Power and Light Company (FPL) provided responses to NRC Open Items and Confirmatory Items identified in the NRC's "Safety Evaluation Report with Open Items Related to the License Renewal of St. Lucie Units 1 and 2," dated February 2003. In response to a conference call with the NRC on April 23, 2003, FPL letter dated May 30, 2003 (L-2003-130) provided supplemental information to support its responses to Open Items 3.0.5.10-1 and 3.1.2.2-1. Based on a review of these responses, the NRC, during a conference call on June 17, 2003, requested additional information regarding the response to Open Item 3.1.2.2-1 related to pressurizer nozzle thermal sleeves. Accordingly, the attachment to this letter contains the response provided in FPL letter L-2003-070, the supplemental information provided in FPL letter L-2003-130, and the supplemental information requested during the June 17, 2003 conference call.

Should you have any further questions, please contact S. T. Hale at (772) 467-7430.

Very truly yours,

William Jefferson, Jr.
Vice President
St. Lucie Plant

WJ/STH/hlo
Attachment

A089

STATE OF FLORIDA )
) ss
COUNTY OF ST. LUCIE )

William Jefferson, Jr. being first duly sworn, deposes and says:

That he is Vice President – St. Lucie Plant of Florida Power and Light Company, the Licensee herein;

That he has executed the foregoing document; that the statements made in this document are true and correct to the best of his knowledge, information and belief, and that he is authorized to execute the document on behalf of said Licensee.

William Jefferson, Jr.

STATE OF FLORIDA

COUNTY OF St. Lucie

Subscribed and sworn to before me this

23 day of June, 2003.

by William Jefferson, Jr. is personally known to me.

Signature of Notary Public – State of Florida

Leslie J. Whitwell
MY COMMISSION # DD020212 EXPIRES
May 12, 2005
BONDED THRU TROY FAIN INSURANCE, INC.

Name of Notary Public (Print, Type, or Stamp)

cc: U.S. Nuclear Regulatory Commission, Washington, D.C.
Program Director, License Renewal & Environmental Impacts
Project Manager, St. Lucie License Renewal
Project Manager, St. Lucie

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**ATTACHMENT**
**SUPPLEMENTAL RESPONSES TO SAFETY EVALUATION REPORT OPEN ITEM FOR REVIEW OF THE ST. LUCIE UNITS 1 AND 2 LICENSE RENEWAL APPLICATION**

**Open Item 3.1.2.2-1:**

The pressurizer surge and spray nozzle thermal sleeves are fabricated from Alloy 600 materials and are welded to the low-alloy steel pressurizer surge and spray nozzles using Alloy 182/82 weld metals. Industry experience has demonstrated that these weld materials are susceptible to PWSCC. In its AMR provided October 3, 2002, the applicant concluded that there are no applicable aging effects for the pressurizer surge and spray nozzle thermal sleeves because the applied loads on the thermal sleeves are low. The attachment welds for the pressurizer surge and spray nozzle thermal sleeves may contain high residual stresses that result from solidification of the weld metal from the molten state. Therefore, the staff concludes that the attachment weld for the pressurizer surge and spray nozzle thermal sleeves may be susceptible to cracking as a result of PWSCC, and that the applicant's supplemental AMR for the pressurizer thermal sleeves needs to be revised to include cracking as an applicable effect for the components.

**FPL Response:** (provided in FPL letter L-2003-070)

This response was provided to the NRC in FPL letter L-2003-070, dated March 28, 2003.

Thermal sleeves are included in the design of the pressurizer surge and spray nozzles and are designed to protect these nozzles from thermal shock. Since the thermal sleeves are not part of the nozzle pressure boundary, their failure would not affect the pressure boundary intended function of these nozzles. However, the thermal sleeves are included in the fatigue analyses of the pressurizer surge and spray nozzles and these analyses have been identified as a time-limited aging analysis (TLAA) and dispositioned in LRA Subsection 4.3.1 (page 4.3-2). Accordingly, the thermal sleeves are considered to be within the scope of license renewal, pursuant to 10 CFR 54.4(a)(2) and require an aging management review.

The pressurizer surge and spray nozzle thermal sleeves are fabricated from Alloy 600 and are exposed to an environment of treated water – primary. The only aging effect requiring evaluation for the thermal sleeves is cracking. Cracking due to stress corrosion or primary water stress corrosion was determined not to be an aging effect requiring management based on the design/fabrication of the sleeves. The thermal sleeves for Units 1 and 2 are constructed from either Alloy 600 pipe or rolled Alloy 600 plate material with a longitudinal seam weld. The sleeves are then machined, inserted into their respective nozzles, and expanded to secure them in place. There are no thermal sleeve attachment welds to the nozzles or any other pressurizer pressure boundary parts. Should cracking of a thermal sleeve longitudinal seam weld occur, the sleeve would spring open relieving the principal stresses and would remain captured by the nozzles. Therefore, the sleeve would continue to perform its intended function. Note that since there is no thermal sleeve weld to the nozzle or any other pressure boundary parts, there is no mechanism for the propagation of a crack to impact pressure boundary intended function. As mentioned above, cracking due to fatigue has been identified as a TLAA and is addressed analytically in LRA Subsection 4.3.1. Accordingly, there are no aging effects requiring management for the thermal sleeves.

Note that this conclusion is consistent with that included in NUREG-1801, "Generic Aging Lessons Learned (GALL) Report." Pressurizer thermal sleeves are included in Chapter IV of the GALL Report, Item C2.5.5. As indicated in the GALL Report table, the aging effect/mechanism identified

for the thermal sleeves is cumulative fatigue damage/fatigue. The GALL Report further states that fatigue is a TLAA for the period of extended operation and further refers to NUREG-1800, "Standard Review Plan for Review of License Renewal Applications for Nuclear Power Plants," Section 4.3 "Metal Fatigue" for acceptable methods for meeting the requirements of 10 CFR 54.21(c)(1). No additional aging effects are identified in the GALL Report for pressurizer thermal sleeves.

<u>Conclusion</u>

Based on the above, FPL requests that Open Item 3.1.2.2-1 be closed.

**<u>FPL Response Supplemental Information:</u>** (provided in FPL letter L-2003-130)

In response to a conference call with the NRC staff on April 23, 2003, the following additional technical information is provided supporting the basis for conclusions regarding potential primary water stress corrosion cracking (PWSCC) of the pressurizer thermal sleeves having a seam weld (i.e., manufactured from plate material).

As indicated in the response to SER Open Item 3.1.2.2-1 above, the Unit 1 and Unit 2 pressurizer nozzle thermal sleeves are either fabricated from Alloy 600 pipe or are rolled from Alloy 600 plate material and seam welded. Specifically, the spray nozzle thermal sleeves are made from pipe, while the surge nozzle thermal sleeves are made from plate material. Due to their welded construction, the aging management review of the surge nozzle thermal sleeves identified their susceptibility to cracking due to PWSCC. However, this aging management review concluded that should cracking of the thermal sleeve longitudinal seam weld occur due to PWSCC, it would not impact the intended function of the sleeve.

PWSCC is intergrannular in nature and therefore, results in a very tight crack geometry. The principle driving force for fluid flow through any through-wall crack in the thermal sleeve would be the differential pressure across the face of the sleeve created by the difference in density between the process fluid and the fluid in the annular space between the sleeve OD and the nozzle. The localized crack geometry when coupled with the very small differential pressure across the face of the sleeve would result in only minor fluid flow. This fluid flow would not be significant in comparison to the equalization holes (three 1/4 inch and two 3/16 inch diameter holes) existing in the thermal sleeve design. These equalization holes provide a total flow area of 0.203 $in^2$. The thermal analysis of the surge nozzle did not specifically model these holes, but assumed natural convection between the thermal sleeve and the nozzle.

In the highly unlikely case that the thermal sleeve longitudinal seam weld was to crack along its entire length, the weld could fail. The sleeve would tend to spring open at the seam to relieve the principal residual stresses, but would remain captured by the nozzle and retainer pins at the sleeve upper end. Because the thermal sleeve is radially restrained/supported at three locations along its length (inlet, the expanded area, and outlet), the potential gap developed at the weld seam during pressurizer steady state (653°F) or hot water insurge/outsurge conditions would be small. This gap is only 0.006 inches maximum at the location below the thermal sleeve expanded area. It opens to up to 0.063 inches at the upper end of the nozzle, and reaches its maximum opening of 0.100 inches within the pressurizer above the nozzle. See Table 3.1.2.2-1.1 below. The additional flow area created by the weld seam gap adjacent to the nozzle during these conditions is 0.032 $in^2$ below the expanded area and 0.340 $in^2$ above the expanded area adjacent to the nozzle.

However, during transients which result in a cold water insurge condition into the pressurizer, the thermal sleeve weld seam gap will open further due to the combined effect of circumferential shrinkage and the residual stresses tending to maintain the sleeve in contact with the nozzle ID.

The pressurizer is affected by a number of insurge transients that have been evaluated in the pressurizer stress report. The most significant one is a reactor trip and loss of load transient, with a minimum temperature of 536°F. Under this limiting transient condition (involving a 117°F temperature differential) the weld seam gap could open 0.035 inches below the thermal sleeve expanded area, 0.097 inches within the nozzle above the expanded area, and reach a maximum opening of 0.133 inches within the pressurizer above the nozzle. The flow area created by the weld seam gap adjacent to the nozzle during these conditions is 0.250 $in^2$ below the expanded area and 0.658 $in^2$ above the expanded area adjacent to the nozzle. See Table 3.1.2.2-1.1 below.

**TABLE 3.1.2.2-1.1**

**Effect of Weld Residual Stresses on Cracked Thermal Sleeve Seam Weld**

| Sleeve Temp. °F | Crack Opening @ Rolled Area in. | Crack Opening @ Nozzle Blend Radius in. | Crack Opening Below Expanded Area in. | Max. Crack Opening Above Nozzle, in. | Limiting Crack Area Adjacent to Nozzle $in.^2$ |
|---|---|---|---|---|---|
| 653 | 0.001 | 0.063 | 0.006 | 0.100 | 0.340 |
| 536 | 0.033 | 0.097 | 0.035 | 0.133 | 0.658 |

The effect of flow through the crack in the thermal sleeve would not have a large effect on the thermal stresses in the pressurizer surge nozzle. However, since the potential crack flow areas exceed the total equalization hole flow area, a bounding analysis has been performed to demonstrate that the nozzle stresses are acceptable. An evaluation of the local effects would require a complex structural and hydraulic model that would consider the effects of fluid mixing and temperature distribution adjacent to the nozzle. To bound the effects, an analysis of the nozzle without the thermal sleeve was conducted. A two dimensional axi-symmetric finite element model was utilized to determine the thermal stresses in the pressurizer surge nozzle at the same locations evaluated in the original pressurizer stress report for Unit 2 (Note: Unit 2 design is identical to Unit 1). Unit 2 was selected based upon a more modern stress analysis and more complete availability of stress report details. In one analysis, thermal stresses are determined using the same thermal boundary conditions that included the thermal sleeve in the pressurizer stress report. A second thermal stress analysis was conducted with the thermal sleeve removed, utilizing forced convection heat transfer coefficients applied directly to the nozzle, in the absence of the thermal sleeve. The thermal stress analysis was conducted in all regions behind the thermal sleeve with the controlling inside surface location being at the nozzle blend radius regions. The fatigue usage factors at this limiting inside surface location increased from 0.002 to 0.0070. At the vessel-to-nozzle weld outside surface, the usage factor increased from 0.018 to 0.020. These are still well below 1.0 and provide ample margin to account for environmental effects.

The results of this analysis demonstrate that the additional flow and convective heat transfer through the gap of a completely cracked thermal sleeve seam weld is accommodated by the significant margin in the existing design.

Additionally, the current analysis of record, which was performed in 1993 to address NRC Bulletin 88-11 (Pressurizer Surge Line Thermal Stratification), determined that the limiting location for the nozzle (based upon stress and fatigue usage factor) is at the surge nozzle to piping weld located upstream of the thermal sleeve. Thus, the limiting location receives no benefit from the thermal sleeve.

Therefore, based upon the above analysis, it is concluded that an Aging Management Program is not required for the Units 1 and 2 pressurizer nozzle thermal sleeves, and that the Units 1 and 2 pressurizer nozzle thermal sleeves will continue to perform their intended function during the period of extended operation.

**FPL Supplemental Response:**

During a telecon on June 17, 2003, the NRC identified a concern that the potential for circumferential cracking on the pressurizer spray and surge nozzle thermal sleeves could result in loose parts. The following supplemental information is provided to address this concern.

Circumferential cracking of Alloy 600 components has occurred in the industry; however, based upon design/fabrication differences, circumferential cracking of the pressurizer nozzle thermal sleeves is not considered a credible aging effect requiring management. Unlike Alloy 600 nozzles which have experienced circumferential cracking and are welded to reactor pressure boundary components around the circumference of the nozzle, the pressurizer nozzle thermal sleeves do not have a circumferential weld, and are not pressure boundary components.

For typical Alloy 600 nozzles, the presence of circumferential cracking is due mainly to the high axial stresses from the weld attaching the nozzle to the hole in the pressure boundary component. The weld shrinkage produces both membrane and bending stresses in the axial direction of the nozzle. Since the nozzles are pressure boundary components, there may also be axial stresses in the nozzles due to pressure. Finally, there may be small bending loads on these nozzles that can result in additional axial stresses. Note that since the thermal sleeves do not have a circumferential weld or a bending load to provide axial stresses, there is no significant driving function for circumferential cracking to occur. Therefore, through-wall circumferential cracking of the thermal sleeves is not considered a credible aging effect.

As described in the response to SER Open Item 3.1.2.2-1 above, the St. Lucie pressurizer surge nozzle thermal sleeves are fabricated from rolled plate material with a longitudinal seam weld, and the pressurizer spray nozzle thermal sleeves are fabricated from seamless pipe. The sleeves are then inserted into the nozzles and locally expanded in a grooved area in the ID of the nozzles. There are no welds attaching the thermal sleeves to any pressure boundary materials. Since the sleeves do not perform a pressure boundary or structural function, they are not exposed to any significant operating stresses other than those related to manufacturing residual stresses (i.e., principally those hoop stresses tending to spring open the sleeve at the longitudinal weld seam). The axial residual stresses due to forming (due to Poisson's ratio effects) are expected to be sufficiently lower than those in the circumferential direction such that any potential PWSCC cracking would occur in the axial direction of the thermal sleeve.

There may be some residual axial bending stresses at the region where the thermal sleeve is explanded into the groove in the nozzle. In the highly unlikely event that a complete circumferential crack occurred in this region, it is not expected that the thermal sleeve would move. Any cracking in the groove region itself would still result in the thermal sleeve remaining captured. The lower portion of the surge nozzle thermal sleeve can not move downward since it is captured in the nozzle (i.e., the nozzle ID is smaller than the thermal sleeve OD). If the cracking was immediately above the groove, the upper portion would not be expected to move upward since only fluid friction loads are available to move the thermal sleeve upward, and these are significantly less than gravity loads that will keep the thermal sleeve in place within the nozzle. Additionally, it is noted that the surge screen assembly within the pressurizer vessel would preclude any part from entering the pressurizer. Likewise, the lower portion of the spray nozzle thermal sleeve is captured by the spray head assembly, and if cracking were to occur above the groove, both gravity and fluid flow would act to prevent the sleeve from entering the spray piping.

In conclusion, based upon the above, circumferential cracking of the thermal sleeves is not an aging effect requiring management.