**UNITED STATES**
**NUCLEAR REGULATORY COMMISSION**
**ADVISORY COMMITTEE ON REACTOR SAFEGUARDS**
**WASHINGTON, DC 20555 - 0001**

July 23, 2012

Mr. R.W. Borchardt
Executive Director for Operations
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: FINAL SAFETY EVALUATION REPORT ASSOCIATED WITH THE FLORIDA POWER AND LIGHT ST. LUCIE, UNIT 2, LICENSE AMENDMENT REQUEST FOR AN EXTENDED POWER UPRATE

Dear Mr. Borchardt:

During the 596th meeting of the Advisory Committee on Reactor Safeguards, July 11-13, 2012, we completed our review of the license amendment request (LAR) for the extended power uprate (EPU) of St. Lucie, Unit 2, (St. Lucie 2) and the associated draft Safety Evaluation (SE). Our Subcommittee on Power Uprates reviewed this matter in a meeting on June 22, 2012. During these reviews, we met with representatives of the staff, Florida Power and Light Company (FPL or the licensee), and their consultants. We did not review the St. Lucie 2 spent fuel pool analysis, which is still under review by the staff. We had the benefit of the documents referenced.

## CONCLUSIONS AND RECOMMENDATION

1. The FPL LAR for an EPU of St. Lucie 2 should be approved subject to the conditions imposed in the staff's draft Safety Evaluation.

2. Fuel thermal conductivity degradation (TCD) phenomena at St. Lucie 2 are addressed by the license condition that FPL maintain more restrictive operational/design radial power fall-off (RFO) curve limits.

3. The licensee's action plan addresses our concerns related to further wear of the tubes in the replacement steam generators (SGs).

## BACKGROUND

The two unit St. Lucie Nuclear Power Plant is located on Hutchinson Island, near Ft. Pierce, Florida in St. Lucie County. Unit 2 is a 2x4 loop pressurized water reactor, designed by Combustion Engineering and licensed in 1983 to operate at 2560 MWt. In 1985, the unit was approved for a 5% stretch uprate to the currently licensed thermal power (CLTP) of 2700 MWt. In this LAR, FPL requested approval of a power uprate of 10% above the CLTP and a 1.7% measurement uncertainty recapture (MUR) to allow a maximum core power level of 3020 MWt. FPL plans to implement this EPU in the fall of 2012.

There are no changes in the reactor coolant system, reactor vessel internals, and fuel type due to the EPU. The two St. Lucie 2 SGs were replaced in 2007 with AREVA Model 86/19TI SGs. The reactor vessel closure head was replaced in 2007.

The EPU will change some core design parameters including fuel enrichment and radial peaking factor, but the maximum linear heat rate will remain the same. The core average coolant temperature will increase from 573.3°F to 578.5°F. The reactor vessel head temperature will increase from about 595°F to 604°F. Design steam mass flow rates in each of the SGs will increase by approximately 13%.

Safety-related changes include control room air conditioning, charging pump control circuits, neutron absorption materials in spent fuel pool storage racks, nuclear steam supply system setpoints, environmental qualification of electrical equipment, component cooling water supports, and the SG low-level trip setpoints. Installation of a Leading Edge Flow Measurement system reduces flow measurement uncertainty and allows a 1.7% increase in power. Some of these changes have already been implemented, and the remaining changes will be completed during the fall 2012 outage.

**DISCUSSION**

We reviewed the staff's evaluation of the EPU effects on station blackout, component material degradation, risk, and electrical power systems. In addition, we considered the licensee's power ascension test program. Issues of special interest that arose during our review are discussed in this letter.

*Fuel Thermal Conductivity Degradation (TCD)*

NRC Information Notice 2009-23, "Nuclear Fuel Thermal Conductivity Degradation," describes an issue concerning the ability of legacy thermal-mechanical fuel modeling codes to accurately predict the exposure-dependent fuel TCD.

The NRC-approved FATES3B fuel rod performance model used by FPL for predicting fuel centerline temperature at high burnup does not model TCD. In response to staff concerns, FPL proposed a license condition that will impose more restrictive operational/design radial power fall-off (RFO) curve limits for St. Lucie 2. The new RFO curve limits were derived by comparing FATES3B fuel temperature predictions to results from Halden fuel tests. FATES3B predictions compared well to Halden data up to intermediate levels of rod average burnup (about 35 GWd/MTU). The predictions underestimate fuel centerline temperatures at higher burnups. New RFO curve limits were determined by imposing in the analysis a penalty that increases from 0-200°F over the burnup range from 35-50 GWd/MTU and remains constant for higher burnups. The staff compared FPL FATES3B fuel temperature predictions that incorporate this RFO curve penalty to Halden data and performed independent FRAPCON-3.4 calculations. Based on these comparisons, the staff concluded that this was acceptable for addressing TCD phenomena at St. Lucie 2. The more restrictive RFO curve limits will be verified as part of the Reload Safety Analysis Checklist process.

*Steam Generator Performance*

Each replacement SG contains 8999 thermally-treated Alloy 690 tubes with broached stainless steel horizontal supports and an anti-vibration bar (AVB) system. The steam generator supplier, AREVA, performed design calculations with their codes to ensure that accumulated SG tube wear was acceptable for 110% CLTP and EPU conditions.

After their first 18 month cycle of operation at the CLTP level, an inspection revealed a number of tube-to-AVB wear indications (3700 indications on 1231 tubes in SG A and 2157 indications on 815 tubes in SG B). Approximately 90% of these wear indicators were less than 15% of the tube wall thickness. Although none of the tube wear reached the 40% wear limit that would require plugging, FPL conservatively plugged the 14 tubes with greater than 25% wear (e.g., 8 tubes in SG A and 6 tubes in SG B). After their second 18 month cycle of operation, inspections found an additional 2164 indications on tubes in SG A and 804 additional indications on tubes in SG B (bringing the total number of affected tubes to 1862 for SG A and to 1125 for SG B). The measured average wear rates reduced from 7.9 to 4.0 %/EFPY for SG A and from 7.7 to 1.6%/EFPY for SG B, but one tube in SG A reached the 40% wear limit for plugging. In addition, the licensee plugged any tubes with measured wear exceeding approximately 30% (a total of 16 additional tubes in SG A and 5 additional tubes in SG B).

The licensee completed a root cause evaluation that considered factors such as SG design, manufacturing processes, materials and associated tolerances, and potential operational effects. They concluded that the root cause was that the U-tubes were not effectively supported during SG manufacture, which caused the tubes to sag into the AVBs and led to slight AVB deformation that closed the tube-to-AVB gap at specific locations. This exacerbated tube wear in those locations. Supporting information for this root cause evaluation included updated AREVA analyses with revised gap distributions that predict wear similar to observed values after the first and second inspections.

The licensee's analyses indicate that the increased steam flow rates associated with the EPU will have a negligible effect on the observed tube wear rates. Results from a third full 100% bobbin coil inspection (scheduled for this fall) will provide additional information. In addition, a full 100% bobbin coil inspection will be conducted after EPU conditions are implemented.

The licensee performed an operational assessment for the next two cycles which included a cycle under EPU conditions. This assessment was based on wear rate data from the first two inspections. The analysis applied a factor of 1.24 to the wear rates to account for the increase in wear rate due to the change in flow conditions for the EPU. The factor of 1.24 is based on an analysis with the tube and support in contact in accordance with the root cause evaluation. The assessment does not credit any additional attenuation of the wear rates that may occur during the current cycle of operation. Assessment results indicate acceptable margin against tube structural integrity requirements, indicating a probability of loss of margin of 0.02 versus an allowable value of 0.05.

The tube wear observed at St Lucie 2 is primarily at AVB supports. This is different than the form of degradation reported to have occurred at San Onofre. There are a number of design differences between the SGs installed at San Onofre and those at St Lucie 2. We reviewed the FPL evaluation of these differences and concluded that the forms of degradation reported to have occurred at San Onofre are less likely to occur at St Lucie 2. This will be verified by the inspection following the first EPU cycle.

These considerations and the licensee's action plan adequately address concerns about SG tube integrity.

**CLOSING COMMENT**

In summary, the EPU license amendment request for St. Lucie 2 should be approved with the license conditions identified in the SER.

Sincerely,

***/RA/***

J. Sam Armijo
Chairman

**REFERENCES**


1. License Amendment Request for Extended Power Uprate, St. Lucie, Unit 2, Docket No. 50-389, Renewed License No. NPF-16, February 25, 2011, (ML110730116).

2. Draft NRC Safety Evaluation on St. Lucie 2 EPU, updated July 2012 (ML12145A032).

3. NRC Review Standard 001 (RS-001), "Review Standard for Extended Power Uprate," Revision 0, December 2003 (ML033640024).

4. CENPD-132, Supplement 4-P-A, Calculative Methods for the C-E Nuclear Power Large Break LOCA Evaluation Model, April 2001 (ML011030417).

5. NRC Information Notice 2009-23, "Nuclear Fuel Thermal Conductivity Degradation," October 8, 2009 (ML091550527).

6. CENPD-139-P-A, Fuel Evaluation Model, July 1974, (ML120960147).

7. CEN-161(B)-P-A, Improvements to Fuel Evaluation Model, August 1989, (ML120960155).

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9. CENPD-275-P, Revision 1-P-A, C-E Methodology for Core Designs Containing Gadolinia-Urania Burnable Absorbers, May 1988.

10. CEN-372-P-A, Fuel Rod Maximum Allowable Gas Pressure, May 1990.

11. CENPD-275-P, Revision 1-P, Supplement 1-P-A C-E Methodology for PWR Core Designs Containing Gadolinia-Urania Burnable Absorbers, April 1999.

12. Letter from B. T. Moroney (NRC) to J. A. Stall (FP&L), St. Lucie Plant, Unit 2 – Issuance of Amendment Regarding Change in Reload Methodology and Increase in Steam Generator Tube Plugging Limit (TAC No. MC1566), January 31, 2005 (ML050120363).

13. CENPD-404-P-A, Revision 0, Implementation of ZIRLOT$^{M}$ Cladding Material in CE Nuclear Power Fuel Assembly Designs, November 2001 (ML013270123 and 013270127).

14. CEN-386-P-A, Verification of the Acceptability of a 1-Pin Burnup Limit of 60 MWD/kgU for Combustion Engineering 16x16 PWR Fuel, ABB Combustion Engineering, Inc., August 1992.

15. CENPD-384-P, Report on the Continued Applicability of 60 MWD/kgU for ABB Combustion Engineering PWR Fuel, ABB Combustion Engineering, Inc., September 1995.

10. CEN-372-P-A, Fuel Rod Maximum Allowable Gas Pressure, May 1990.

11. CENPD-275-P, Revision 1-P, Supplement 1-P-A C-E Methodology for PWR Core Designs Containing Gadolinia-Urania Burnable Absorbers, April 1999.

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15. CENPD-384-P, Report on the Continued Applicability of 60 MWD/kgU for ABB Combustion Engineering PWR Fuel, ABB Combustion Engineering, Inc., September 1995.

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