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

FPL

April 5, 2012

L-2012-147
10 CFR 50.90

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

Re: St. Lucie Plant Unit 1
Docket No. 50-335
Renewed Facility Operating License No. DPR-67

Response to NRC Nuclear Performance and Code Review Branch Request for Additional Information Regarding Extended Power Uprate License Amendment Request

References:

(1) R. L. Anderson (FPL) to U.S. Nuclear Regulatory Commission (L-2010-259), "License Amendment Request (LAR) for Extended Power Uprate," November 22, 2010, Accession No. ML103560419.

By letter L-2010-259 dated November 22, 2010 [Reference 1], Florida Power & Light Company (FPL) requested to amend Renewed Facility Operating License No. DPR-67 and revise the St. Lucie Unit 1 Technical Specifications (TS). The proposed amendment will increase the unit's licensed core thermal power level from 2700 megawatts thermal (MWt) to 3020 MWt and revise the Renewed Facility Operating License and TS to support operation at this increased core thermal power level. This represents an approximate increase of 11.85% and is therefore considered an Extended Power Uprate (EPU).

During a phone call on March 22, 2012 the NRC staff requested additional information related to the analysis of post-LOCA boric acid precipitation in support of their review of the St. Lucie Unit 1 EPU License Amendment Request (LAR). The attachment to this letter transmits the requested information.

This submittal contains no new commitments and no revisions to existing commitments.

This submittal does not alter the significant hazards consideration or environmental assessment previously submitted by FPL letter L-2010-259 [Reference 1].

A001
A002
NRR

In accordance with 10 CFR 50.91(b)(1), a copy of this letter is being forwarded to the designated State of Florida official.

Should you have any questions regarding this submittal, please contact Mr. Christopher Wasik, St. Lucie Extended Power Uprate LAR Project Manager, at 772-467-7138.

I declare under penalty of perjury that the foregoing is true and correct to the best of my knowledge.

Executed on 05-April-2012

Very truly yours,

Richard L. Anderson
Site Vice President
St. Lucie Plant

Attachment

cc: Mr. William Passetti, Florida Department of Health

**Response to NRC Nuclear Performance & Code Review Branch
Request for Additional Information**

By letter L-2010-259, dated November 22, 2010, Accession Number ML103560419, Florida Power & Light (FPL) requested to amend the St. Lucie Unit 1 Renewed Facility Operating License to increase the licensed core thermal power level from 2700 megawatts thermal (MWt) to 3020 MWt, which constitutes an extended power uprate (EPU).

During a phone call on March 22, 2012 the NRC staff requested additional information related to the analysis of post-LOCA boric acid precipitation in support of their review of the St. Lucie Unit 1 EPU License Amendment Request (LAR). Two questions were identified during the phone call; these questions have been paraphrased by FPL. The questions and responses are provided below.

**Question 1**

**Provide clarification of the lower plenum temperature prior to sump recirculation, and how that temperature would affect boric acid precipitation. Specifically, the NRC Staff noted the following from their own confirmatory analysis:**

> **Note the concentration spike at about 45 min. is about 12.5 wt%, which marks the beginning of lower plenum mixing at a lower plenum temperature of about 140 °F (Note, the precipitation limit at 140 °F is 12.97 wt%). One needs to show that the concentration in the core, when safety injection flow begins to enter and mix with the lower plenum, is below the precipitation limit at the min lower plenum temperature.**

**Response**

The boric acid analysis does not explicitly calculate the temperature in the lower plenum. The analysis assumes saturation at atmospheric conditions, which is conservative, as it maximizes core boil-off.

Following a large break loss-of-coolant accident (LBLOCA), safety injection (SI) comes from the refueling water tank (RWT) prior to sump recirculation. This is the timeframe being examined for this response, so all SI will come from the RWT. RWT minimum liquid temperature is 51 °F. This time in the LOCA long term cooling transient is also before simultaneous hot and cold leg injection, so all SI is being injected into the cold legs, and travels down the downcomer to the lower plenum. The core region is at much hotter, saturation conditions (i.e., 212 °F) due to decay heat.

The liquid temperature distribution in the reactor vessel during long term cooling would be expected to be subcooled single phase liquid in the lower plenum, subcooled to saturated liquid in the lower core region, and saturated two-phase liquid-vapor in the remainder of the core region and outlet plenum region. This represents a hydrodynamically stable condition, i.e., the layers (less dense atop more dense) will remain heterogeneous unless a destabilizing force is applied. Up to the point of the transfer to sump recirculation, the coolant is an aqueous boric acid solution. Boric acid is only mildly miscible in the vapor phase so it accumulates in the liquid phase as boiling occurs in the core region. The accumulation of solute can provide the destabilizing force needed to produce convection (heat and mass transport) between the layers.

Therefore, the lower plenum region would be at a temperature between 51°F and 212 °F during the time following a LBLOCA prior to sump recirculation. The LBLOCA ECCS performance analysis calculates downcomer liquid temperature during reflood, which can be used to approximate lower plenum temperature during this time.

The information provided for downcomer liquid temperature as part of this response is based on the St. Lucie Unit 2 LBLOCA analysis. Though there are differences between the two units, the major inputs (core power, initial RCS temperatures, plant geometry, safety injection flow, etc.) are similar enough that approximating the Unit 1 lower plenum temperature using a Unit 2 analysis has been judged to be appropriate for this response.

Per the St. Lucie Unit 2 LBLOCA ECCS performance analysis, the downcomer liquid temperature is 130 °F during the refill/reflood timeframe.

Note that in support of a separate NRC RAI for St. Lucie Unit 2 (SRXB-113; see Reference a.) a figure was generated that only calculates the downcomer liquid temperature out to 500 seconds post-LOCA (approximately 8 minutes). However, the limiting LBLOCA case that this figure is based on was run out to 900 seconds post-LOCA (i.e., 15 minutes) and shows a downcomer liquid temperature of 130 °F at that time as well. Due to the steady-state nature of the downcomer liquid temperature seen in the figure, it is judged to be appropriate to use this value for the entire period post-LOCA prior to sump recirculation.

Based on the solubility of boric acid in water at atmospheric pressure and 130 °F, the solubility limit in the lower plenum prior to sump recirculation is 11.54 wt%. As documented in the request above, the NRC Staff notes a spike in concentration of up to 12.5 wt% at 45 minutes post-LOCA, which is in the timeframe prior to sump recirculation. This spike is above the solubility limit at the assumed lower plenum temperature, which would cause boric acid to precipitate. For the solubility limit to be above 12.5 wt% the minimum lower plenum temperature would need to be approximately 140 °F. At 140 °F, the solubility limit is 12.97 wt%.

The LBLOCA analysis assumes no condensation of steam in the cold legs after the safety injection tanks (SITs) have emptied. Including this condensation would increase the temperature of the SI liquid from the RWT before it reaches the downcomer. The current analysis models no condensation to calculate liquid temperatures, which results in the SI liquid entering the downcomer at the RWT temperature (i.e., 51 °F). In support of a separate NRC RAI for St. Lucie Unit 2 (SRXB-112), Westinghouse evaluated the effect of accounting for both partial condensation and full condensation in the cold legs. This evaluation concluded that accounting for even partial condensation in the cold legs results in a significant increase in fluid enthalpy in the downcomer. By 500 seconds post-LOCA, the downcomer is approaching saturation conditions. Based on Figure 1c from the response to RAI SRXB-112 (Reference a.), the liquid enthalpy can be conservatively estimated to be 190 BTU/lbm. At a pressure of 14.7 psia and enthalpy of 190 BTU/lbm, the temperature of liquid in the downcomer would be 212 °F.

Taking credit for condensation of steam in the cold legs shows that the lower plenum temperature prior to sump recirculation, based on the liquid temperature in the downcomer, would be approximately 212 °F, i.e., the assumed saturation temperature. The boric acid solubility limit associated with this temperature is 29.27 wt%. Therefore, the solubility limit in the lower plenum during this time will remain above the 12.5 wt% spike in boric acid concentration noted by the NRC Staff, and boric acid precipitation in precluded.

References

a. R. L. Anderson (FPL) to U.S. Nuclear Regulatory Commission (L-2012-131), "Response to NRC Reactor Systems Branch Request for Additional Information Regarding Extended Power Uprate License Amendment Request," April 5, 2012.

## Question 2

**Provide clarification of the steps that would be taken to ensure that cooling is assured in the long term and boric acid precipitation is precluded for small breaks in the event the shutdown cooling (SDC) system is not available due to a single failure. Additionally, the timing for any time-dependent operator actions should be included and justified.**

## Response

The long term cooling (LTC) plan for a loss of coolant accident provides the analytical steps necessary to determine that both the core remains sufficiently cooled and boric acid precipitation is precluded for all break sizes. For large break sizes, simultaneous hot and cold leg injection is initiated between 4-6 hours post-LOCA. The simultaneous hot and cold side injection is maintained, both to remove heat from the core and to provide a flushing flow, keeping the boric acid concentration in the core below the solubility limit. If the break is sufficiently small and SDC entry pressure and temperature are reached, the SDC system is placed in service.

In the event that shutdown cooling is not available and cannot be recovered, an alternate method of cooldown is available for small breaks, namely a feed and bleed cooling method.

For St. Lucie Unit 1, the limiting condensate storage tank depletion time is 14 hours for a 2 atmospheric dump valve (ADV) SG cooldown. Plant emergency operating procedures direct the operator to initiate feed and bleed cooling when both steam generator levels reach less than 15% wide range level. This criteria provides sufficient time to enable the operators to initiate feed and bleed cooling prior to losing the SGs as heat sink.

Opening the PORVs and injecting SI into the cold legs will provide the "feed and bleed" necessary for small breaks to keep the core covered (ensuring cooling of the core) and produce the flushing flow necessary to keep the boric acid concentration below the solubility limit.