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

FPL

October 20, 2011

L-2011-442
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.

(2) Email from T. Orf (NRC) to C. Wasik (FPL), "St. Lucie Unit 1 EPU draft RAIs – Boric Acid Precipitation (Nuclear Performance & Code Review SNPB)," August 16, 2011.

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).

By email from the NRC Project Manager dated August 16, 2011 [Reference 2], additional information related to St. Lucie Unit 1 boric acid precipitation was requested by the NRC staff in the Nuclear Performance & Code Review Branch (SNPB) to support their review of the EPU License Amendment Request (LAR). The request for additional information (RAI) submitted via Reference 2 identified eight questions. The responses to these RAIs are provided in the Attachment to this letter.

A001
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.

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

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

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 20-October-2011

Very truly yours,

Richard L. Anderson
Site Vice President
St. Lucie Plant

Attachment

cc: Mr. William Passetti, Florida Department of Health

Response to Request for Additional Information

The following information is provided by Florida Power & Light Company (FPL) in response to the U. S. Nuclear Regulatory Commission's (NRC) Request for Additional Information (RAI). This information was requested to support Extended Power Uprate (EPU) License Amendment Request (LAR) for St. Lucie Nuclear Plant Unit 1 that was submitted to the NRC by FPL via letter (L-2010-259) dated November 22, 2010, Accession Number ML103560419.

In an email dated August 16, 2011 from NRC (Tracy Orf) to FPL (Chris Wasik), Subject: St. Lucie 1 EPU draft RAIs – Boric Acid Precipitation (Nuclear Performance and Code Review, SNPB), the NRC requested additional information regarding FPL's request to implement the EPU. The RAI consisted of eight questions from the NRC's Nuclear Performance and Code Review Branch (SNPB). These eight RAI questions and the FPL responses are documented below.

SNPB-8

Please provide the following information for the St. Lucie 1 NSSS:

a. **Volume of the lower plenum, core and upper plenum below the bottom elevation of the hot leg, each identified separately. Also provide heights of these regions**

b. **Loop friction and geometry pressure losses from the core exit through the steam generators to the inlet nozzle of the reactor vessel. Also, provide the locked rotor RCP k-factor. Please provide the mass flow rates, flow areas, k-factors, and coolant temperatures for the pressure losses provided (upper plenum, hot legs, SGs, suction legs, RCPs, and discharge legs). Please include the reduced SG flow areas due to plugged tubes. Please also provide the equivalent loss coefficient through the loop to a break in the single broken cold leg. Also identify the flow area (hydraulic diameter) the k-factors are based on.**

Response

a. The volumes and heights of the lower plenum, core, and upper plenum are documented in Table 1 below.

Table 1
RCS Volumes, Areas and Elevation / Heights

Parameter	Value (units)
Lower Plenum	
Height of the Lower Plenum	10.1875 ft
Volume of the Lower Plenum	871.5 ft^3

Table 1
RCS Volumes, Areas and Elevation / Heights

Active Core (actual, i.e., no voids)	
Height of the Active Core	11.392 ft
Area of the Active Core	54 ft^2
Volume of the Active Core	615.17 ft^3
Outlet Plenum (top of active core to bottom of the Core Support Barrel (CSB) Nozzles)	
Height of the Outlet Plenum	3.56 ft
Volume of the Outlet Plenum	334.6 ft^3

b. The loop friction and geometry pressure losses requested in Part B are documented below in Tables 2 through 4, along with Figures 1 and 2, which are provided for informational purposes. Additionally, Table 2 and Figure 2 provide information on the reactor vessel, which was not specifically asked for, but provided for completeness.

Table 2
Calculation of Station-to-Station Reactor Vessel K-Factors (Figure 2)

Reactor Vessel						
Station	**Flow (lbm/hr)**	**Specific Volume (ft^3/lbm)**	**ΔPg (psi)**	**ΔPf (psi)**	**Kg* (Acore)**	**Kf* (Acore)**
1-2	1.3776E+08	0.021251	0.59		0.564	
90°	1.3776E+08	0.021251	5		4.776	
2-3	1.3776E+08	0.021251	0.12		0.115	
3-4	1.3776E+08	0.021251	0.45		0.430	
4-5	1.3776E+08	0.021251	0.44		0.420	
5-6	1.3776E+08	0.021251	0.01		0.010	
6-7 (fric)	1.3776E+08	0.021251		0.2		0.191
7-8	1.3776E+08	0.021251	0.16		0.153	
8-s	1.3776E+08	0.021251	3.56		3.400	
s-9	1.3776E+08	0.021251	0.07		0.067	
9-11	1.3776E+08	0.021251	1.7		1.624	
11-13	1.3776E+08	0.021251	0.23		0.220	
13-15	1.3776E+08	0.021251	2.51		2.397	
15-17	1.3197E+08	0.021251	1.18		1.228	
17-a (fric)	1.3197E+08	0.022147		4.02		4.015
17-a	1.3197E+08	0.022147	4.88		4.873	
a-18 (fric)	1.3197E+08	0.022147		0.23		0.230

Table 2
Calculation of Station-to-Station Reactor Vessel K-Factors (Figure 2)

a-18	1.3197E+08	0.022147	0.8		0.799	
18-20	1.3197E+08	0.023211	0.74		0.705	
20-24	1.3776E+08	0.023211	6.53		5.710	

*10% uncertainty has been applied to the pressure drop values to calculate Kg and Kf

Additionally, the flow area used in these calculations is the core flow area (Acore = 54.00 ft^2).

ΔPg: Delta pressure (geometric losses)
ΔPf: Delta pressure (frictional losses)
Kg: Geometric losses K-factor
Kf: Frictional losses K-factor

Table 3

Calculation of Loop Station-to-Station K-Factors Excluding SG Sections (Figure 1)

Section	ΔPf (psi)	ΔPg (psi)	Flow Rate (10^6 lbm/hr)	Density (lbm/ft^3)	Kf* (Acore)	Kg* (Acore)
1-2	0.19	0	73.768	43.258	0.582	0.000
2-3	0.19	0.88	73.768	43.258	0.582	2.940
8-9	0.39	2.16	36.884	46.780	5.166	31.212
9-10	0.39	1.5	36.884	46.780	5.166	21.675
11-12	0.28	0	36.884	46.780	3.709	0.000
12-13	0.28	1.2	36.884	46.780	3.709	17.340

*10% uncertainty has been applied to the pressure drop values to calculate Kf (frictional losses) and 20% uncertainty has been applied to the pressure drop values to calculate Kg (geometric losses).

Additionally, the densities provided in Table 3 above are based on the cold and hot leg coolant temperatures at EPU conditions. The flow area used in these calculations is the core flow area (Acore = 54.00 ft^2).

The reactor coolant pump locked rotor K-factor, based on the core flow area, is 1626.21, where 13.39 is the locked rotor K-factor and 4.9 ft^2 is the area that the locked rotor K-factor is based on.

ΔPg: Delta pressure (geometric losses)
ΔPf: Delta pressure (frictional losses)
Kg: Geometric losses K-factor
Kf: Frictional losses K-factor

Table 4

Calculation of SG Station-to-Station K-Factors (Figure 1)

Section	Flow Area (ft^2)	Kf (Asg)	Kg (Asg)	Kf* (Acore)	Kg* (Acore)
3-4	9.62	0	0.484	0	18.301
4-5	18.22	0	0.34	0	3.584
5-6	18.22	0.0128	0.16	126.793	1.687
6-7	18.22	0	0.47	0	4.954
7-8	9.82	0	0.09	0	3.266

*10% uncertainty has been applied to the calculation of Kf (frictional losses) and 20% uncertainty has been applied to the calculation of Kg (geometric losses).

Additionally, the flow area used in these calculations is the core flow area (Acore = 54.00 ft^2). The total flow area in the steam generator tubes, accounting for 10% tube plugging, is 18.22 ft^2 (Asg).

Kg: Geometric losses K-factor
Kf: Frictional losses K-factor

Figure 1

Reactor Coolant System Loop Sections

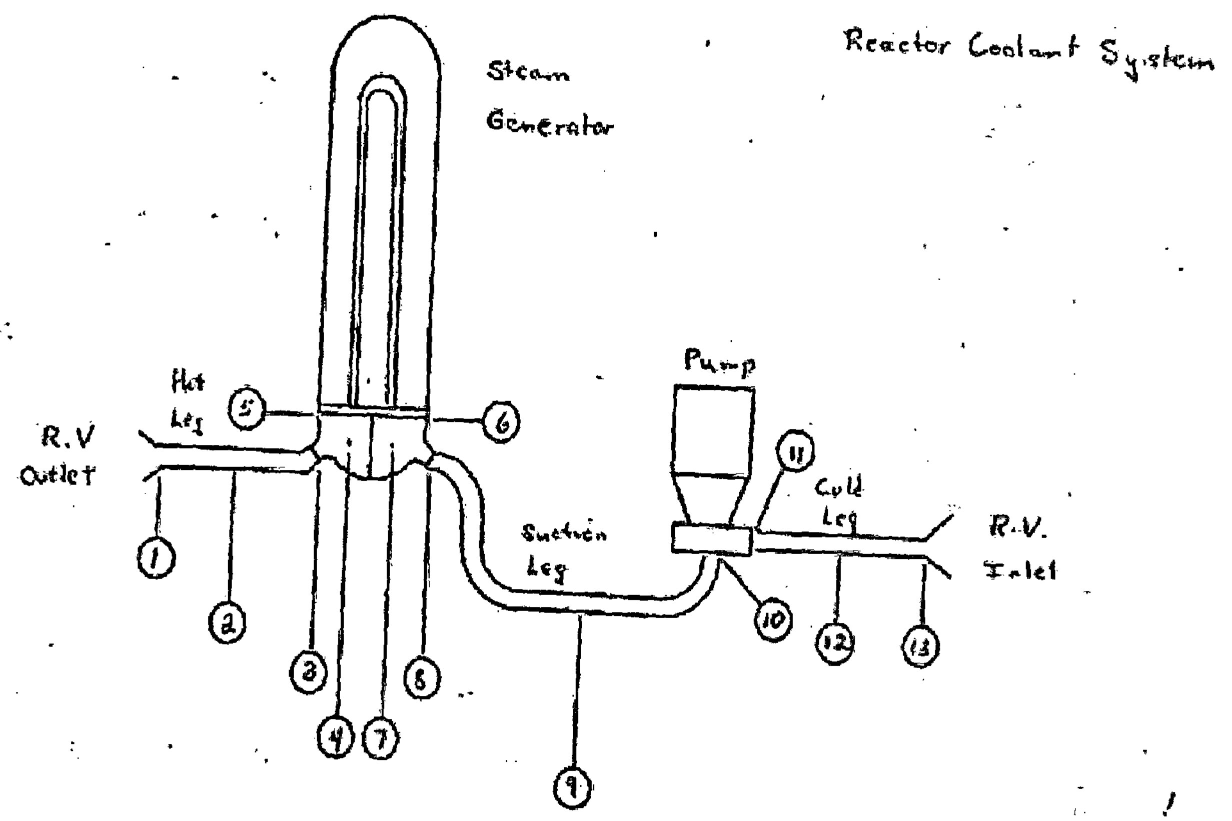
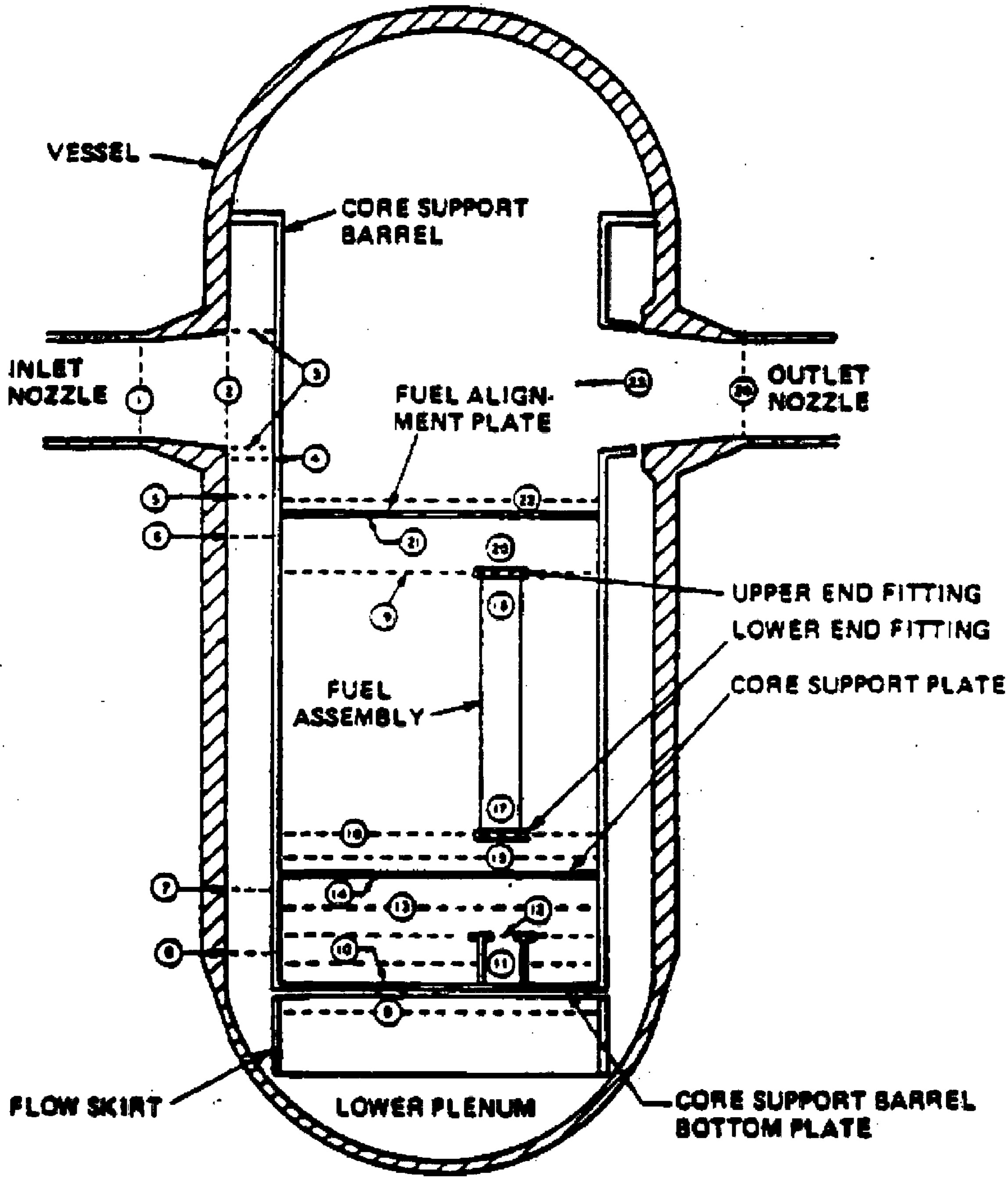


Figure 2

Reactor Vessel Stations



SNPB-9

What is the sump temperature vs time following recirculation and how does this impact precipitation? Is the boric acid concentration in the vessel below the precipitation limit based on the minimum sump temperature at the time the switch to simultaneous injection is performed? Please explain. What is the minimum temperature in the lower plenum just prior to recirculation actuation?

Response

The BORON analysis assumes a constant core steam enthalpy and core inlet liquid enthalpy based on saturation conditions at 14.7 psia. Therefore, the analysis assumes a constant transient sump temperature, specifically 212 °F. The precipitation limit is also based on a saturation pressure of 14.7 psia, which corresponds to a temperature of 212 °F. The current calculation of the precipitation limit is conservative, as it is based on a conservative pressure of 14.7 psia, which the NRC has required based on a letter dated November 23, 2005 (ADAMS Accession No. ML053220569). The minimum temperature in the lower plenum is not explicitly modeled or calculated in the BORON code, but any temperature calculations are based on 212 °F. This is the liquid temperature at a saturation pressure of 14.7 psia, which is used per the NRC issues in the November 23, 2005 letter.

SNPB-10

Since SIT actuation terminates the PCT for the 0.07 ft^2 clb and does not for the 0.06 ft^2 limiting break, please demonstrate that there is no worse break between 0.07 and 0.06 ft^2.

Response

FPL provided supplemental information to the NRC via letter L-2011-206 dated May 27, 2011 (ADAMS Accession number ML11153A048). Attachment 1 to the referenced transmittal is AREVA report ANP-3000(P), "St. Lucie Unit 1 EPU – Information to Support License Amendment Request." Information pertaining to determination of the limiting break size is addressed in Section 2.2.1 of the AREVA report.

SNPB-11

Were the BAM tanks assumed to discharge following the limiting large break LOCA with respect to boric acid precipitation? What EOP guidance is given regarding termination of the BAM tanks following a LOCA? What is the minimum lower plenum fluid temperature prior to recirculation and is this temperature below the precipitation limit? What is the earliest and latest timing for the switch to recirculation? Please explain.

Response

The boric acid precipitation analysis conservatively assumes complete discharge of the BAM tanks. This is a conservative departure from the EOP guidance, which in step 34 instructs to realign charging pump suction from the BAM tanks to an alternate source when the BAM tanks are at a level of between 20-30%.

BORON analysis results show that, using a conservatively large initial volume for the BAM tanks, they empty at approximately 2.3 hours. The code conservatively assumes saturation temperature at 14.7 psia, which minimizes the liquid mass in the vessel and minimizes the precipitation limit. The switch to simultaneous hot and cold side injection must occur between 4-6 hours, to preclude boric acid precipitation. These timings show that BAM tanks empty prior to the switch to simultaneous hot and cold side injection.

SNPB-12

What is the uncertainty in flow rates for the flow split between the hot and cold leg injection and was this taken into account? At 6 hrs, the hot side injection is equal to the boil-off rate. If the hot side injection is less than boil-off, flushing will not begin until sufficient flow in excess of the boil-off is injected. Please explain.

Response

The hot leg/cold leg injection strategy employs the use of multiple pumps (high pressure safety injection, low pressure safety injection and containment spray pumps) and multiple flow paths, with one pump supplying hot leg injection flow while a high pressure safety injection pump simultaneously supplies cold leg injection flow. Therefore, there is no flow split between hot and cold leg injection. The minimum hot leg injection capability, including uncertainty, exceeds 250 gpm. The boric acid precipitation analysis results assume a conservative hot side injection flow rate of 250 gpm. Thus, the minimum required hot leg injection flow rate is provided.

At 6 hours, hot side injection (250 gpm) approximately equals the boil-off rate, and therefore, flushing begins post 6 hours. The analysis credits flushing only after hot side injection exceeds the boil-off rate. Flushing is equal to the hot side injection minus the boil-off rate.

SNPB-13

What is the effect of axial power shape on precipitation timing? Bottom peaks reduce the liquid inventory in the mixing volume. Please provide the most bottom skewed axial power distribution.

Response

A limiting bottom peaked axial power shape does not necessarily correspond to the power shape associated with the decay heat that corresponds to the steady state operation at full power.

In the boric acid precipitation analysis, the axial power shape is only used in calculating the mixing volume for boric acid precipitation. The justification for use of the flat power shape is as follows:

> A flat axial power shape is selected as a reasonably conservative representation of the axial power distribution. In this calculation, a bottom peaked shape (i.e., positive axial shape index (ASI)) is in a conservative direction since it results in more bubbles being produced lower in the core and, consequently, more level swell (i.e., higher void fraction). In general, long term axial power shapes start out at beginning of cycle as cosine shapes and transition to saddle shapes later in cycle. These shapes are generally fairly symmetrical and, hence, have ASIs that are close to 0. A flat axial power shape is a conservative representation of this fact since it maximizes the power at the bottom of the core.

To evaluate the impact of bottom peaked shapes, using a more conservative version of the St. Lucie Unit 1 Cycle 24 bottom peaked axial power shape with ASI equal to +0.2, the mixing volume calculation was recalculated. Using this power shape resulted in a 1% reduction in the mixing volume. This is expected to have a negligible effect on the results of the boric acid precipitation analysis. The bottom peaked axial power shape used for this calculation is documented below:

Mixing Volume Region*	Height (feet)	Axial Peaking Factor
1	10.1875	0
2	1.1392	1.2
3	1.1392	1.3
4	1.1392	1.3
5	1.1392	1.2
6	1.1392	1.1
7	1.1392	1.0
8	1.1392	0.9
9	1.1392	0.8
10	1.1392	0.7
11	1.1392	0.5
12	7.6	0

*Mixing Volume Region 1 is the lower plenum, and Region 12 is the outlet plenum

SNPB-14

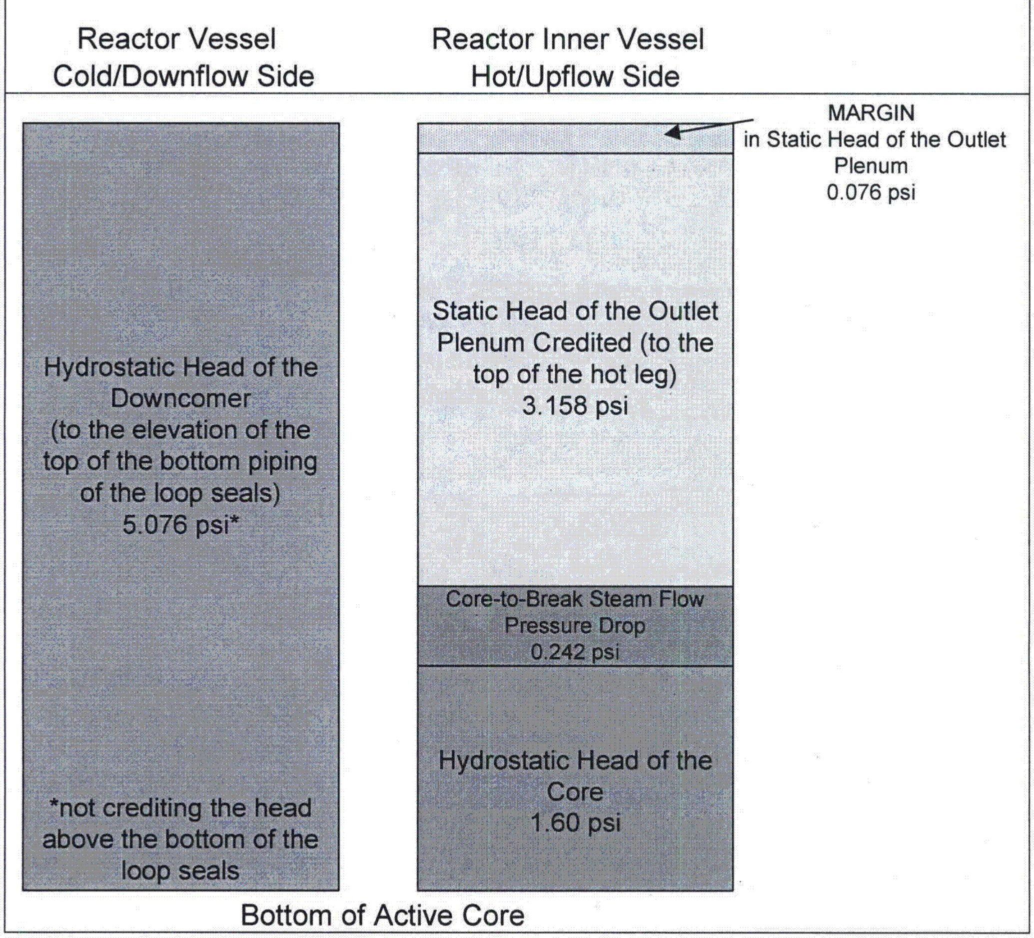
What is the impact on precipitation timing for breaks on the top of the cold leg with the loop seal region assumed filled with liquid with the core steaming rate bubbling through the vertical section at the pump suction piping? Please explain.

Response

In response to NRC Acceptance Review Question #5 for St. Lucie Unit 1, Westinghouse has already constructed a response to demonstrate that the limiting break assumed in the boric acid precipitation analysis, a double-ended break in the cold leg, is in fact the most limiting. The response, which has been incorporated in LR Section 2.8.5.6.3.5.2, calculates the reactor vessel hydrostatic pressure balance, and the margin that is available to overcome any additional pressure due to loop seal clearing. Figure 3 summarizes these calculations.

Figure 3

Reactor Vessel Hydrostatic Pressure Balance
For Boric Acid Precipitation Analysis
(Regions Shown to Scale at 6 Hours Post-LOCA)



The discussion of how loop seal refilling and clearing is accounted for from LR Section 2.8.5.6.3.5.2 has been included below, to provide a full response to this RAI, and is as follows:

The above Figure 3 represents a slot break at the top of the cold leg. This includes the potential additional pressure drop due to the loop seals refilling as well as an additional pressure drop due to a higher level for the downcomer liquid, described as follows:

- Loop seal refilling will increase the value of the core-to-break steam flow pressure drop, which will reduce the margin calculated above.
- Note that the hydrostatic head above the bottom of the cold legs does not need to be included since it balances on the downcomer and loop seal side of the hydrostatic pressure balance.

To demonstrate that a slot break at the top of the cold leg is capable of clearing the loop seals, the loop seals hydrostatic head is calculated and deducted from the hydrostatic head of the downcomer. For the pressure balance to be acceptable, either the pressure must be equal, or it must be shown that there is still margin in the static head of the outlet plenum.

Using the geometric information tabulated in Table 2.8.5.6.3-10 in LR Section 2.8.5.6.3.5.2, the height of the loop seal (from top of cross-over leg to bottom of discharge leg) is 3.5 ft for St. Lucie Unit 1. The static head associated with the height of liquid in the cold leg above the loop seal inlet to the reactor coolant pump is offset by the added static head for the downcomer from this liquid. The pressure drop, ignoring the head of steam in the downflow side of the loop seal, associated with clearing the liquid in the upflow side of the loop seal is calculated as follows:

$$\Delta P_{DC} = 3.5 \text{ ft} / 0.016714 \text{ ft}^3/\text{lbm} / 144 \text{ in.}^2/\text{ft}^2 * g/g_c = 1.454 \text{ psi}$$

This pressure drop has been deducted from the hydrostatic head of the downcomer. Constructing a reactor vessel hydrostatic pressure balance based on this, there remains 0.076 psi available margin in the pressure balance for the break in the top of the cold leg. Therefore, the pressure balance is acceptable, and the loop seals can be cleared. Note that the above calculation was done assuming zero void fraction in the loop seals. As noted in the RAI, steam would bubble through the vertical section of the loop seal. This will decrease the hydrostatic head of the loop seals and provide additional margin.

Other potential break locations are even less limiting and do not need to be evaluated. For example, if the break was in the loop seal, the above calculation of the pressure drop due to loop seal refilling is not required. Comparatively, the double ended break in the cold leg is still bounding.

Therefore, according to this argument, the boron precipitation analysis will not be affected by the described phenomena of the refilling of the loop seals. This includes the calculation of precipitation timing, which remains bounding and the same.

SNPB-15

What provisions in the long term cooling plan are made in the event shutdown cooling is unavailable? Please explain.

Response

The break spectrum for long term cooling is analyzed to assure that for each break size, at least one of two success paths are achievable – either the plant can enter shutdown cooling or simultaneous hot and cold side injection can adequately cool down the plant. For St. Lucie Unit 1, this analysis was performed for both a 1 ADV and a 2 ADV cool down. Additionally, for the 1 ADV cool down, the decision to enter shutdown cooling must be made prior to 32 hours post-LOCA, and 12 hours for the 2 ADV cool down.

For a 1 ADV cool down, breaks 0.010 ft^2 and larger can be cooled through simultaneous hot and cold side injection, while breaks 0.029 ft^2 and smaller can enter shutdown cooling. Similarly, for a 2 ADV cool down, breaks 0.013 ft^2 and larger can be cooled through simultaneous hot and cold side injection, and breaks 0.024 ft^2 and smaller can enter shutdown cooling. Each break spectrum shows a pressure overlap larger than twice the pressurizer pressure measurement uncertainty of ±80 psi. Therefore, all break sizes can be adequately cooled down in the event of a LOCA.

The analysis assumes that one ECCS train is available. Note that St. Lucie Unit 1 has two ECCS trains. Thus, shutdown cooling is available and one HPSI pump along with a LPSI/CS pump are available to provide simultaneous hot and cold leg injection. Thus, there is no need to enter into a feed and bleed mode of cool down.