ATTACHMENT 2

Response to NRC Reactor Systems Branch Request for Additional Information Regarding Extended Power Uprate License Amendment Request

NON-PROPRIETARY VERSION

(Cover page plus 49 pages)

ANP-3019(NP)
Revision 0

St. Lucie Unit 1 EPU – Information to Support NRC Review of Steam Generator Tube Rupture

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AREVA NP Inc.

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ANP-3019(NP)
Revision 0

St. Lucie Unit 1 EPU – Information to Support NRC Review of Steam Generator Tube Rupture

Nature of Changes

Item	Page	Description and Justification
1.	All	Initial Release

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Nomenclature

Acronym	Definition
ADV	Atmospheric Dump Valve
AFAS	Auxiliary Feedwater Actuation Setpoint
AFW	Auxiliary Feedwater
ANS	American Nuclear Society
EOP	Emergency Operating Procedure
EPU	Extended Power Uprate
ESF	Engineered Safety Feature
ESFAS	Engineered Safety Feature Actuation System
FF	Feed Flow
FPL	Florida Power & Light
FSAR	Final Safety Analysis Report
HPSI	High Pressure Safety Injection
LAR	License Amendment Request
LOCA	Loss of Coolant Accident
LOOP	Loss of Offsite Power
LR	Licensing Report
MD AFW	Motor-Driven Auxiliary Feedwater
MFW	Main Feedwater
MSIV	Main Steam Isolation Valve
MSSV	Main Steam Safety Valve
MTO	Margin to Overfill
NR	Narrow Range
NRC	Nuclear Regulatory Commission
PORV	Power Operated Relief Valve
PT	Pressure Temperature
RCGVS	Reactor Coolant Gas Vent System
RCP	Reactor Coolant Pump
RCS	Reactor Coolant System
RPS	Reactor Protection System
RTP	Rated Thermal Power

Nomenclature *(Continued)*

Acronym	Definition
SBCS	Steam Dump and Bypass Control System
SDC	Shutdown Cooling
SE	Safety Evaluation
SF	Steam Flow
SG	Steam Generator
SGTP	Steam Generator Tube Plugging
SGTR	Steam Generator Tube Rupture
SI	Safety Injection
SIAS	Safety Injection Actuation Signal
TD AFW	Turbine-Driven Auxiliary Feedwater
TM/LP	Thermal Margin/Low Pressure

1.0 Introduction

The Nuclear Regulatory Commission (NRC) staff requested additional information to support the review of the steam generator tube rupture (SGTR) section of the St. Lucie Unit 1 extended power uprate (EPU) license amendment request (LAR). The questions were received as "draft" questions specifically related to steam generator (SG) overfill. However, the NRC subsequently requested similar information for the SGTR steam release analysis. The questions for SG overfill were modified to adapt them accordingly to steam releases.

The information contained herein is specific to the analyses supporting the St. Lucie Unit 1 EPU LAR submittal.

2.0 SGTR Overfill

2.1 *Summary of Analysis*

A conservative SGTR overfill analysis was performed to address the NRC questions concerning SG overfill.

A single case was analyzed. Parameter biasing, assumptions, and an assumed single failure were designed to produce a conservatively high break flow rate, maximize Auxiliary Feedwater (AFW) flow to the ruptured SG, and minimize the Margin to Overfill (MTO) at the time operators terminate AFW flow to the ruptured SG. Assumptions regarding operator actions and mitigating systems and functions, along with a limiting single failure, produce the most challenging scenario regarding SG overfill. The case analyzed is described below.

The SGTR event is initiated by a double-ended break of a single steam generator tube (shortest tube) on the top side of the tubesheet. The break is assumed to be at the cold-side of the U-tube at the top surface of the tube sheet above the SG outlet plenum. A cold-side break is analyzed because it produces a higher total break flow rate than a hot-side break, which is in the conservative direction for the overfill analysis.

Loss of Offsite Power (LOOP) is assumed at reactor trip in this analysis. The assumption of LOOP at reactor trip is conservative relative to offsite power being available, as safety grade overfill protection for Main Feedwater (MFW) would be available and would prevent SG overfill in a no-LOOP case.

There are no operator actions or mitigating systems or functions simulated directly in this analysis to cooldown and depressurize the Reactor Coolant System (RCS) to equilibrate RCS and ruptured SG pressures and terminate break flow. Therefore, the calculated integrated break flow will bound an actual integrated break flow (out to the time that operators terminate AFW flow to the ruptured SG) that would occur when operators take mitigating steps in accordance with the Emergency Operating Procedures (EOPs). The only operator action directly accounted for in the analysis is termination of Turbine-Driven (TD) AFW flow to the ruptured SG following Auxiliary Feedwater Actuation Setpoint (AFAS) reset when the ruptured SG Narrow Range (NR) level reaches 35%, plus a 15 minute delay time for operator action.

Along with no operator actions or mitigating systems or functions being directly simulated to terminate break flow, the most challenging single failure to overfill of the ruptured SG is a failed open TD AFW flow control valve on AFAS reset. This produces the largest AFW flow to the ruptured SG, which reduces the ruptured SG pressure and tends to increase the break flow rate. Without this single failure, the AFAS reset logic will prevent AFW flow to the ruptured SG when the nominal SG level is above 29% NR (analysis value 35% NR).

The maximum ruptured SG liquid volume at the time operators terminate TD AFW flow to the ruptured SG was calculated to be 5879.1 ft^3. The total secondary side volume of the SG is 7733.7 ft^3. Thus, the MTO is 1854.6 ft^3 at the time of ~28 minutes when operators terminate AFW flow to the ruptured SG. This MTO of greater than 1850 ft^3, calculated with conservative break flow, would be sufficient to prevent SG overfill considering the fact that operators will be taking action to reduce the SG level and reduce the pressure difference between the RCS and the ruptured SG, which would result in reduced break flow. The conservative break flow at the time of termination of AFW flow was ~42 lbm/sec. Even assuming continuation of this break flow up to 45 minutes into the transient with no other operator action, the MTO will remain greater than 1000 ft^3.

The sequence of events for the SGTR overfill analysis is shown in Table 1.

Figure 1 shows the liquid volume in the ruptured SG versus time relative to the total geometric volume of the SG. The MTO is 1854.6 ft^3 at the time the operators terminate AFW flow to the ruptured SG (28.7 minutes).

Table 1 Sequence of Events for SGTR Overfill Case

Time (s)	Event
0.0	Event initiation - Double-ended rupture of SG tube occurs above tubesheet on cold plenum side
0.0	Charging flow begins
229.1	Thermal Margin/Low Pressure (TM/LP) Reactor Protection System (RPS) setpoint reached (including delay time)
229.1	Turbine trips on reactor trip – offsite power is assumed lost
229.1	Reactor Coolant Pumps (RCPs) coastdown due to LOOP
229.1	MFW lost due to LOOP
232	Main Steam Safety Valves (MSSVs) open on ruptured SG (SG-1)
232	MSSVs open on intact SG (SG-2)
241.1	AFAS signal on SG-1 and SG-2
421.1	AFW flow begins to SG-1 and SG-2
772.0	Safety Injection Actuation Signal (SIAS)
794	Pressurizer empties
1098	High Pressure Safety Injection (HPSI) flow begins
821.4	SG-1 NR level reaches 35% following reactor trip
1721.4	TD AFW to SG-1 is terminated

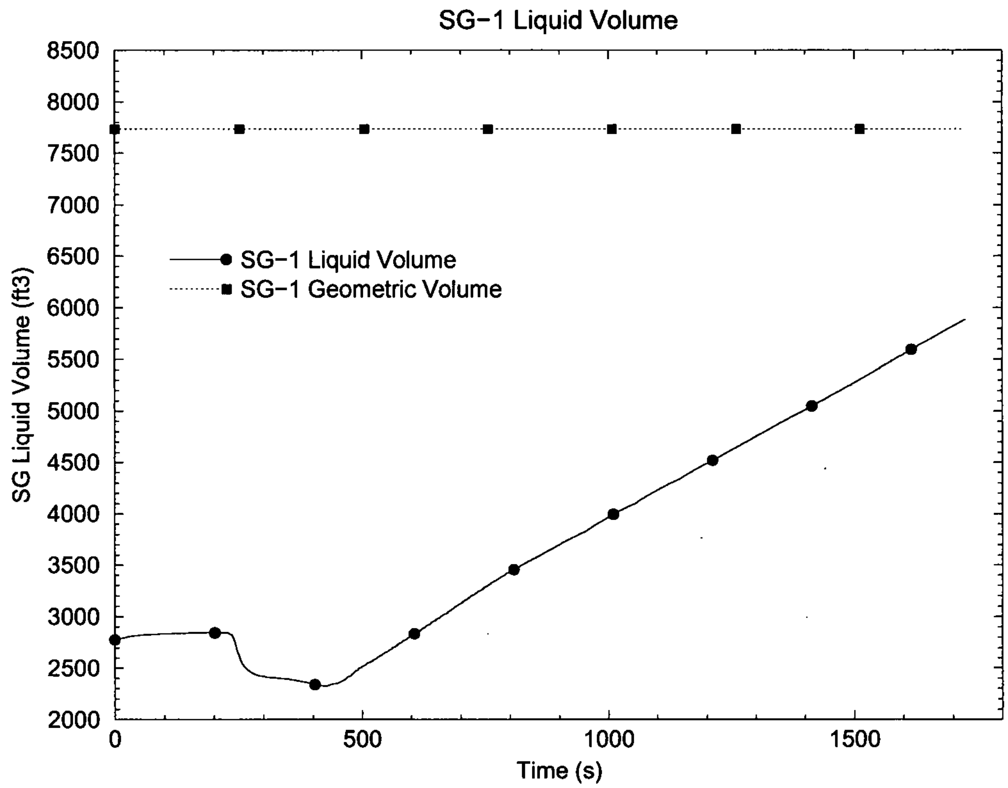

Figure 1 SGTR Overfill – Ruptured SG Liquid Volume

2.2 *Responses to Information Request*

SRXB-1: Discuss the methodologies and computer codes used for the SGTR overfill analysis. If the methods were previously approved by U. S. NRC, list the NRC safety evaluations (SEs) approving the methods and address the compliance with the restrictions listed in the SEs. If the methods were not reviewed and approved by NRC, address acceptability of the methods. Discuss the mitigation strategies used in the SGTR analysis to the conditions that the break flow is terminated or the shutdown cooling system can be used for decay heat removal.

Response: The purpose of the SGTR overfill analysis was to conservatively calculate the MTO for the ruptured SG at the time operators terminate AFW flow to the ruptured SG. A detailed analysis was performed with the approved methodology using the S-RELAP5 code (Reference 1). The S-RELAP5 code was used to model the key primary and secondary system components, RPS and engineered safety features (ESF) actuation trips and core kinetics. The nodalization, chosen parameters, conservative input and sensitivity studies were reviewed for applicability to this event in compliance with the SE for the Reference 1 topical report.

- The nodalization used for the SGTR calculations supporting the EPU was specific to St. Lucie Unit 1 and was consistent with the Reference 1 methodology. Nodalization diagrams used for the non-Loss of Coolant Accident (LOCA) event analyses for the EPU are given in Figure 2 to Figure 4. The normal non-LOCA model lumps all of the tubes in a SG together. The SGTR model has one SG tube modeled explicitly, with the remainder lumped. The rupture model is a double-ended guillotine break in this tube just above the tube sheet. Critical flow is modeled using the Moody model, which provides a conservative model for choked flow.
- The parameters and equipment states were chosen to provide a conservative estimate of the MTO for the ruptured SG at the time operators terminate AFW flow to the ruptured SG. The biasing and assumptions for key input parameters are discussed in response to SRXB-2.
- The S-RELAP5 code assessments documented in Reference 1 validated the ability of the code to predict the response of the primary and secondary systems during transient events. The assessments included the non-LOCA LOFT test suite. No additional code assessments were performed.

The analysis did not model specific operator actions to cooldown and depressurize the RCS, equilibrate RCS and ruptured SG pressures, and terminate break flow. Thus, the calculation predicted a conservative break flow rate out to the time that operators terminate AFW flow to the ruptured SG, based on a much larger pressure difference between the RCS and ruptured SG than would occur when operators initiate EOP actions to cooldown and depressurize the RCS, equilibrate RCS and ruptured SG pressures, and terminate the break flow. Thus, a conservative MTO at the time operators terminate AFW flow to the ruptured SG was calculated.

Figure 2 Non-LOCA Reactor Vessel Nodalization

Figure 3 Non-LOCA Reactor Coolant System Nodalization

Figure 4 Non-LOCA Secondary System Nodalization

SRXB-2: List the nominal values with measurement uncertainties and the corresponding values used in the SGTR overfill analysis for the following plant parameters:

- Initial power level
- Initial RCS and SG pressure
- Initial SG water inventory
- Initial pressurizer water volume
- Safety injection actuation pressure setpoint
- Safety injection flow versus RCS pressure
- Safety injection system pump delay time
- SG relief valve pressure setpoint
- AFAS and delay time
- AFW temperature and flow rate per SG
- MSSV lift setpoints and steam flow rate of each MSSV
- Time of loss of offsite power
- Atmospheric dump valve (ADV) steam flow rate from intact and affected SGs
- Decay heat model and initial value in percentage of the rated power level

This discussion should include rationale to show that the value of each of the above parameters used in the SGTR overfill analysis is conservative, resulting in a minimum margin to SG overfill. In addition, provide a basis for the target cooldown temperature used in the analysis.

Response: Table 1 provides the requested information for the SGTR overfill analysis. The key parameters were biased to maximize the break flow, maximize AFW flow to the ruptured SG, and produce a conservative MTO at the time operators terminate AFW flow to the ruptured SG. Since specific operator actions to cooldown and depressurize the RCS were not used in the analysis, there was no specific target cooldown temperature in the analysis. The cooldown of the RCS that did occur was a result of AFW flow to both SGs with its associated cooldown and depressurization of the SGs. The RCS hot leg temperature was reduced to 505°F at the end of the calculation due to cooling from AFW.

Table 2 Input Parameter Biasing for the SGTR Overfill Analysis

Table 2 Input Parameter Biasing for the SGTR Overfill Analysis *(Continued)*

Table 2 Input Parameter Biasing for the SGTR Overfill Analysis *(Continued)*

Table 2 Input Parameter Biasing for the SGTR Overfill Analysis *(Continued)*

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Table 3 Maximum HPSI Flow Rates for the SGTR Overfill Analysis

RCS Pressure (psia)	Loop 1A Flow Rate (gpm)	Loop 1B Flow Rate (gpm)	Loop 2A Flow Rate (gpm)	Loop 2B Flow Rate (gpm)
15	296	395	395	395
324	259	346	346	346
633	216	288	288	288
839	182	243	243	243
1045	140	187	187	187
1148	114	153	153	153
1158	112	149	149	149
1162	110	147	147	147
1251	80	107	107	107
1303	55	74	74	74

Table 4 Auxiliary Feedwater Flow Rates

SG Pressure (psia)	MD AFW Flow Rate to Ruptured SG (gpm)	TD AFW Flow Rate to Ruptured SG (gpm)	MD AFW Flow Rate to Intact SG (gpm)
115	725.55	738.15	691
515	581.70	599.55	554
815	457.80	474.60	436
915	411.60	425.25	392
1000	368.55	379.05	351

(Note: MD and TD AFW flow rates to the ruptured SG include a 5% bias high)

SRXB-3: Identify operator actions and associated action times credited in the analysis. Where an operator action is credited, confirm that such action is consistent with station procedure and action times are conservative, resulting in a minimum SG MTO.

Response: Specific operator actions to cooldown and depressurize the RCS, equilibrate RCS and ruptured SG pressures, and terminate break flow were not modeled in the analysis. Thus, the calculation predicted a conservative break flow rate relative to the break flow rate that would occur when operators initiate EOP actions to equilibrate RCS and ruptured SG pressures to terminate the break flow to the ruptured SG. This produces a conservative MTO at the time operators terminate AFW flow to the ruptured SG. The only operator action directly credited in the analysis was to terminate TD AFW flow to the ruptured SG after the NR level reached 35%, plus a 15 minute delay time for operator action. Per EOPs, operators will continue to equilibrate RCS and ruptured SG pressures using ADVs, PORVs, and pressurizer auxiliary spray to terminate the break flow and isolate the ruptured SG by 45 minutes. Table 5 contains an assessment of the operator actions relative to SGTR MTO.

Table 5 SGTR Operator Actions

Key EOP Operator Actions	Impact	Comment
If turbine not tripped, then operator trips it locally and closes both main steam isolation valves (MSIVs).	MSIV isolation increases pressure in SG, so level goes down.	None.
Operator verifies at least one SG level is being restored to between 60% to 70% by feedwater or AFW.	SG level restored by AFW.	None.
Operator maintains RCS Tave between 525 and 535°F and S/G pressure between 835 and 915 psig by using the steam dump and bypass control system (SBCS) or opening the ADVs.	SG pressure may go down and level go up based on AFW flow.	For LOOP, ADVs can be locally opened. Single failure of valve failing open is not credible. For no LOOP, the SBCS is used. With failure of SBCS, ADVs will be used.
Operator/Shift Technical Advisor verifies every 15 minutes: unisolated SG level is being restored to 60% to 70% NR. For high SG level, the level is reduced by controlling/stopping AFW, lowering RCS pressure, SG blowdown, steaming to condenser or steaming with ADVs.	Maintains heat sink.	Level is controlled to be within this band. This action applies to both SGs before isolating the affected SG. The actions for high level will prevent the SG level from rising further.
Operator cools down RCS to less than 510°F using SBCS, all ADVs, AFW motor pumps, or AFW steam driven pump taking steam from least affected SG.	SG level goes down as the steam flow (SF) is increased to cooldown [SF > feed flow (FF)]. SG pressure goes down, and level goes up again as SG is cooled with AFW.	None.
Operator maintains RCS below 930 psia and within 50 psia of most affected SG. Operator depressurizes RCS using pressurizer sprays, power operated relief valves (PORVs) or reactor coolant gas vent system (RCGVS).	Primary to secondary leakage is minimized.	This action is performed continuously before isolating the affected SG.

Table 5 SGTR Operator Actions *(Continued)*

Key EOP Operator Actions (EOP-01 and EOP-04)	Impact	Comment
Operator isolates most affected SG and maintains pressure less than 915 psig using MSIV bypass if vacuum (minimize release), control room operation of ADVs, or local operation of ADV if no instrument air.	Release from affected SG stops. (radiological impact)	This action is supposed to occur before or at the analysis assumed time limit (45 minutes).
Operator cools down to shutdown cooling (SDC) using SBCS or ADVs.	Unisolated SG pressure goes down.	As RCS Temperature is lowered, cooling the isolated SG, the isolated SG pressure will lower.
Operator maintains isolated SG level less than 90% NR by lowering RCS pressure, SG blowdown, steaming to condenser or steaming with ADVs.	Stops SG level increase.	None.

SRXB-4: Under the assumed LOOP conditions, address the functionality of each ADV. Discuss what, if any, mitigating function of the ADV provides, and its capability to perform that function under assumed LOOP conditions. If the valve's actuation must be manual, provide information to show that the operator is capable of actuating the valve within the analytical assumed time.

Response: Since specific operator actions to cooldown and depressurize the RCS were not used in the analysis, the ADVs were not used.

SRXB-5: One of the key parameters that may significantly affect the results of the SG MTO analysis during an SGTR event is the initial SG water level, which is a function of the initial power level. The MTO analysis should consider the effects of the initial SG water levels corresponding to power levels that capture 95 percent of the operating time during a fuel cycle. Also, for the range of the power levels that envelop 95 percent of the operating time, provide trending data for the corresponding SG water level to show that conservative initial SG water levels (with inclusion of measurement uncertainty and plant conditions perturbation) have been used in the steam release analysis.

Response: The SG overfill analysis used an initial SG mass corresponding to operation at 85% of RTP. However, the MTO at the time the operators terminate AFW flow to the ruptured SG is not sensitive the initial SG mass. The only effect the initial SG mass has would be to change the time 35% NR is reached in the ruptured SG, and therefore, the time that operators terminate AFW flow to the ruptured SG.

SRXB-6: List systems, components and instruments that are credited for consequence mitigation of the SGTR MTO analysis in accordance with the St Lucie 1 SGTR EOP. Discuss whether each system and component specified is safety grade. For SG ADVs and control valves, specify the valves motive power and discuss if the motive power and valve controls are safety grade. For non-safety grade systems and components, discuss whether safety grade backups are available that can be expected to function or provide the desired information within a time frame compatible with prevention of SGTR overfill or justify that non-safety grade systems and components can be used for the SGTR overfill analysis. Provide a list of all radiation monitors that could be used for identification of the SGTR event and the affected SG, and specify the quality and reliability of the instrumentation, as appropriate. If the EOP specifies SG sampling as a means of affected SG identification, provide the expected time period for obtaining the sample results and discuss the effects on the duration of the SGTR event.

Response: The systems actuated during the event analysis were the Reactor Protection System, Engineered Safety Feature Actuation System (ESFAS) (HPSI, AFW, and Charging) and steam line MSSVs. The Reactor Protection System, ESFAS and steam line MSSVs are safety grade components and/or systems. No additional systems, components, or instruments, other than ruptured SG NR level, were directly credited for consequence mitigation in the SGTR overfill calculation. The SG NR level feeds into the AFAS logic which is a part of safety grade AFW system.

SRXB-7: List the single failure events considered in the SGTR overfill analysis and identify the worst single failure used in the analysis that resulted in a minimum MTO. Provide justification if single failure event is not considered in the analysis.

Response: Specific operator actions to cooldown and depressurize the RCS, equilibrate RCS and ruptured SG pressures, and terminate break flow (out to the time operators terminate AFW flow to the ruptured SG) were not modeled in the analysis in order to predict a conservative break flow rate. In combination with these assumptions, the limiting single failure is one that produces the highest AFW flow rate. The single failure used in the analysis was an assumed failure to close one AFW flow control valve on the ruptured SG (i.e. valve failed open on TD AFW pump after reaching the AFAS reset). The AFW flow control valves normally open on AFAS and close at the AFAS reset setpoint. The increased AFW flow, after a NR level of 35% in the ruptured SG is reached, reduces the MTO at the time operators terminate AFW flow to the ruptured SG (i.e. 35% NR plus a 15 minute delay time for operator action to terminate the AFW flow).

3.0 SGTR Steam Release

3.1 *Summary of Analysis*

The responses contained in this section are relative to the analysis of the steam releases for SGTR dose provided in St. Lucie Unit 1 EPU LAR Attachment 5, LR Section 2.8.5.6.2, Steam Generator Tube Rupture. In this analysis, most of the steam from the unaffected SG was diverted to be released through the MSSVs on the ruptured SG steam line by not taking credit for the steam line reverse flow check valves. All the steam released from the MSSVs on the ruptured SG steam line was assumed to be from the ruptured SG resulting in conservative radioactive releases and hence conservative dose.

The SGTR analysis assumes operator action time of 45 minutes to isolate the affected SG. Specifically, at 45 minutes, operators are assumed to stop the steam releases from the affected SG and are assumed to have taken control of RCS pressure, SG level and SG pressure.

Prior to 45 minutes, operators will be performing actions per EOPs to cooldown and depressurize the RCS via steam releases from the secondary system. These actions would tend to reduce the break flow and the radioactive releases, which would be beneficial from dose considerations. These actions are not credited in determining the radioactive releases from the affected SG in the EPU LAR analysis.

Prior to 45 minutes, with the offsite power available, operators would perform RCS cooldown using the SBCS, discharging the steam to the condenser. In the event of failure of SBCS, ADVs would be used to cooldown the RCS (instrument air available) with no additional failure assumed. For the case of LOOP, SBCS will not be available and the loss of instrument air will render ADVs inoperational from the control room. In this case, ADVs would be operated locally with manual action, with no assumed failure for local manual operation of ADV.

3.2 *Responses to Information Request*

SRXB-STM-1: Discuss the methodologies and computer codes used for the SGTR steam release analysis. If the methods were previously approved by U. S. NRC, list the NRC SEs approving the methods and address the compliance with the restrictions listed in the SEs. If the methods were not reviewed and approved by NRC, address acceptability of the methods. Discuss the mitigation strategies used in the SGTR analysis to the conditions that the break flow is terminated or the shutdown cooling system can be used for decay heat removal.

Response: The purpose of the steam release analysis was to conservatively calculate the steam releases to the atmosphere for input to the radiological dose analyses. Detailed analyses were performed with the approved methodology (Reference 1) using the S-RELAP5 code. The S-RELAP5 code was used to model the key primary and secondary system components, RPS and ESF actuation trips and core kinetics. The nodalization, chosen parameters, conservative input and sensitivity studies were reviewed for applicability to this event in compliance with the SE for the Reference 1 topical report.

- The nodalization used for the SGTR calculations supporting the EPU was specific to St. Lucie Unit 1 and was consistent with the Reference 1 methodology. Nodalization diagrams used for the non- LOCA event analyses for the EPU are given in Figure 2 to Figure 4. The normal non-LOCA model lumps all of the tubes in a SG together. The SGTR model has one SG tube modeled explicitly, with the remainder lumped. The rupture model is a double-ended guillotine break in the single tube just above the tube sheet. Critical flow is modeled using the Moody model which provides a conservative model for choked flow.
- The parameters and equipment states were chosen to provide a conservative estimate of the steam releases. The biasing and assumptions for key input parameters is discussed in response to SRXB-STM-2.
- The S-RELAP5 code assessments documented in Reference 1 validated the ability of the code to predict the response of the primary and secondary systems during transient events. The assessments included the non-LOCA LOFT test suite. No additional code assessments were performed.

Subsequent to the isolation of ruptured SG, a heat balance was performed to determine the steam releases resulting from the cooldown of the plant to a RCS temperature of 212°F. The heat balance considered energy contributions from decay heat, heat structures and the fluid within the primary and secondary systems. Steam releases were calculated for various cooldown rates, i.e., 20°F/hr, 25°F/hr, 30°F/hr, 38°F/hr and 100°F/hr. The steam releases were subsequently used in the dose analyses.

The analysis did not model specific operator actions prior to 45 minutes. It was assumed in the analysis that the operators would initiate EOP actions to isolate the ruptured SG by 45 minutes after which plant cooldown would commence. In accordance with the plant EOPs, the primary system cooldown to SDC system entry conditions was accomplished by the ADV in the intact SG.

SRXB-STM-2: List the nominal values with measurement uncertainties and the corresponding values used in the SGTR steam release analysis for the following plant parameters:

- Initial power level
- Initial RCS and SG pressure
- Initial SG water inventory
- Initial pressurizer water volume
- Safety injection actuation pressure setpoint
- Safety injection flow versus RCS pressure
- Safety injection system pump delay time
- SG relief valve pressure setpoint
- AFW actuation setpoint and delay time
- AFW temperature and flow rate per SG
- MSSV lift setpoints and steam flow rate of each MSSV
- Time of loss of offsite power
- ADV steam flow rate from intact and affected SGs
- Decay heat model and initial value in percentage of the rated power level

This discussion should include rationale to show that the value of each of the above parameters used in the SGTR steam release analysis is conservative, resulting in a maximum steam release. In addition, provide a basis for the target cooldown temperature used in the analysis.

Response: St. Lucie Unit 1 EPU LAR Attachment 5, LR Section 2.8.5.6.2, Steam Generator Tube Rupture, provides an analysis of the steam releases for SGTR dose analyses (identified herein as the Reference Case). Steam releases from the ruptured SG considered all the steam released through the MSSVs on the ruptured SG steam line, although significant portion of this steam was from the unaffected SG (no credit for the reverse flow check valves). As a result, 182705 lbm of contaminated steam was released from the ruptured SG. Conservative steam release from the ruptured SG resulted in a conservative calculation of dose.

Table 8 provides a discussion relative to the biasing of parameters for the steam release analyses. Key parameters were biased to maximize the environmental steam release. To demonstrate the conservative nature of the steam release analysis, several supporting evaluations were performed to evaluate initial pressurizer pressure and level, AFW delay time, SI temperature, charging system actuation, charging flow temperature and RPS trip time.

Table 6 summarizes the parameter biasing used in each of the supporting evaluations. Key results are provided in Table 7. Table 7 provides the total integrated break flow and integrated steam releases from the time of trip to 45 minutes. Prior to trip, steam is assumed to flow through the turbine to the condenser. The key difference between the Reference Case and the supporting cases relative to dose is the difference in the steam releases assumed from the ruptured SG. In the Reference Case, 182705 lbm of steam was assumed to be released from the ruptured SG, although significant portion of the steam released from the ruptured SG MSSVs was from the unaffected SG. That effluent would be treated (in the dose calculations) as if it all were at the ruptured SG activity level. In the supporting cases, roughly one-third of the total mass release was through the intact SG MSSVs; that flow would be at a much lower activity level. In the supporting cases, only approximately two-thirds of the total steam release would thus be at a high activity level and approximately one-third would be treated at a lower activity level. The maximum total steam release through the ruptured SG of [ ] lbm (Case E) was much less than that for the Reference Case. These results indicate that the Reference Case with a higher ruptured SG steam release would remain conservative for dose consequences.

Once the ruptured SG was isolated at 45 minutes, the cooldown of the RCS initiated with the ADV in the intact SG. From 45 minutes to SDC, cooldown rates of 20°F/hr, 25°F/hr, 30°F/hr, 38°F/hr and 100°F/hr were assumed. The SDC entry conditions are defined as 325°F ± 25°F and 267 psia. For the purposes of calculating conservative steam releases, the analysis assumed cooldown to a temperature of 212°F.

Table 6 Supporting Evaluations Case Definitions

Table 7 Summary of Results for Supporting Evaluations of Input Parameter Biasing

Table 8 Input Parameter Biasing for the SGTR Steam Release Thermal-Hydraulic Analysis

Table 8 Input Parameter Biasing for the SGTR Steam Release Thermal-Hydraulic Analysis *(Continued)*

Table 8 Input Parameter Biasing for the SGTR Steam Release Thermal-Hydraulic Analysis *(Continued)*

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Table 8 Input Parameter Biasing for the SGTR Steam Release Thermal-Hydraulic Analysis *(Continued)*

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Table 9 Maximum HPSI Flow Rates for Steam Release Thermal-Hydraulic Analysis

RCS Pressure (psia)	Loop 1A Flow Rate (gpm)	Loop 1B Flow Rate (gpm)	Loop 2A Flow Rate (gpm)	Loop 2B Flow Rate (gpm)
15	296	395	395	395
324	259	346	346	346
633	216	288	288	288
839	182	243	243	243
1045	140	187	187	187
1148	114	153	153	153
1158	112	149	149	149
1162	110	147	147	147
1251	80	107	107	107
1303	55	74	74	74

SRXB-STM-3: Identify operator actions and associated action times credited in the analysis. Where an operator action is credited, confirm that such action is consistent with station procedure and action times are conservative, resulting in a maximum steam release.

Response: The analysis did not model specific operator actions prior to 45 minutes. Steam releases were assumed to occur via the ruptured SG MSSVs. It was assumed that the operators would initiate EOP actions to isolate the ruptured SG by 45 minutes after which plant cooldown would commence. In accordance with the plant EOPs, the primary system cooldown was accomplished by the ADV in the intact SG.

Table 10 contains an assessment of the SGTR EOP (1-EOP-04) actions relative to the SGTR steam releases. If the operators followed the EOPs, the results would be less limiting compared to the analysis where no operator action was assumed for 45 minutes.

Table 10 Assessment of EOP Actions for SGTR Steam Releases

EOP Action	Disposition
Ensure SI actuation	SI is modeled to automatically actuate at time of reactor trip with no time delay in the analysis.
Maximize SI flow Ensure all charging pumps are running	Maximum HPSI and charging flow are modeled in the analysis.
Cooldown to T_{HOT} < 510°F using ADVs locally from <u>both</u> SGs.	The analysis modeled steam releases with no operator action to reduce the pressure difference between the RCS and the ruptured SG. If cooldown was initiated using the ADVs from both SGs, the steam release would be approx. split equally between the two SGs. As the ADVs are operated to cooldown the RCS temperature, the operators depressurize the RCS as necessary to minimize the break flow as the ruptured SG pressure decreases with ADV operation. In the analysis, the conservative combination of steam releases from ruptured SG MSSVs with no operator action to reduce the pressure difference between the RCS and the ruptured SG is judged to bound cooldown using the ADVs for both SGs with RCS depressurization.
Depressurize the RCS - Maintain RCS pressure within pressure-temperature (PT) limits - Maintain pressure less than 930 psia - Maintain minimum pressure above value for RCP operation - Maintain pressure within 50 psi of affected SG - Operate main or aux. spray - Throttle HPSI, if criteria met	The analysis does not model RCS depressurization since the effect would be beneficial in reducing break flow.
Protect main condenser on LOOP	LOOP assumed in analysis. Releases are modeled to the atmosphere and not to the condenser.
Restore instrument air on LOOP	ADVs operated locally until instrument air is restored. Analysis assumes ADVs don't operate prior to 45 minutes.
Isolate most affected SG if RCS hot leg temperature is less than 510°F	Ruptured SG is assumed to be isolated at 45 minutes. Earlier isolation decreases the steam releases from the ruptured SG.
Maintain ruptured SG < 930 psia.	The analysis did not model maintenance of the ruptured SG pressure < 930 psia since the operators would also depressurize the RCS to < 930 psia and maintain RCS pressure within 50 psi of ruptured SG. These actions would be beneficial in reducing break flow.
RCS cooldown to SDC (LOOP) - Unisolated SG ADV used - Maximum cooldown is 30°F in any 1 hour period	 Analysis used ADV from intact SG for RCS cooldown Analysis assumed various cooldown rates to SDC.

Table 10 Assessment of EOP Actions for SGTR Steam Request *(Continued)*

EOP Action	Disposition
Maintain ruptured (isolated) SG Level < 90% NR - Lower RCS pressure (most preferred method) - Use SG blowdown to MST - Steam to atmosphere (least preferred method)	The ruptured SG level does not reach 90% by 45 minutes in the analysis. Minimizing SG inventory maximizes the steam releases to the atmosphere and increases the concentration of the radioactive releases.
RCP restart, if criteria is met	Analysis assumes natural circulation to increase the time to SDC entry conditions.
Cool and depressurize the isolated SG (in order listed) - If at least one RCP is running, then drain to 40% NR and feed to 90% NR - If at least one RCP is running, then drain to 10% NR and control level at ~10% NR - Steam to condenser using SBCS - Blowdown to 40% NR and feed to ~90% NR - Cool by ambient losses - Steam to atmosphere using ADV or turbine-driven AFW pump and alternate steaming paths	Multiple options are available to cool and depressurize the ruptured SG. The least preferred means from a radiological standpoint is steaming to the atmosphere using the ADV or alternate steaming paths. The analysis assumed that the cooldown to SDC entry conditions is not by steaming the ruptured SG to the atmosphere. This is consistent with the EOP actions to cool and depressurize the ruptured SG by means other than steaming to the atmosphere.
Enter to SDC Operation	SDC entry conditions assumed to be RCS P = 267 psia and RCS T = 212°F

SRXB-STM-4: Under the assumed LOOP conditions, address the functionality of each ADV. Discuss what, if any, mitigating function of the ADV provides, and its capability to perform that function under assumed LOOP conditions. If the valve's actuation must be manual, provide information to show that the operator is capable of actuating the valve within the analytical assumed time.

Response: If LOOP occurs, instrument air is lost to both ADVs and the ADVs fail closed. The analysis assumes that steam releases occur solely from the SG MSSVs to 45 minutes at which time the operators isolate the ruptured SG. RCS cooldown is then modeled using the ADV on the intact SG. Once the ruptured SG is isolated at 45 minutes, it is assumed that the operators will have restored instrument air per the EOPs. If instrument air cannot be restored, the ADVs can be locally operated.

Scenarios run on the simulator will show that the local operation of ADV during a SGTR is achieved well within 45 minutes. The current Final Safety Analysis Report (FSAR) analysis supports an operator action time of 30 minutes. No changes to EOP actions result from the EPU analyses.

SRXB-STM-5: List systems, components and instruments that are credited for consequence mitigation of the SGTR steam release analysis in accordance with the St Lucie 1 SGTR EOP.

Response: Up to 45 minutes, the systems actuated during the event analysis were the Reactor Protection System, ESFAS (HPSI, AFW, and Charging) and steam line MSSVs. The Reactor Protection System, ESFAS and steam line MSSVs are safety grade components and/or systems. No operator action was assumed for the first 45 minutes after which the ruptured SG is isolated in accordance with the EOPs. From 45 minutes to the time of SDC entry, it was assumed that the operators would cool the plant down to SDC entry conditions. During cooldown to SDC, the analysis assumed that energy removal would occur by way of atmospheric steam releases from the intact SG ADV.

SRXB-STM-6: List the single failure events considered in the SGTR steam release analysis and identify the worst single failure used in the analysis that resulted in a maximum steam release. Provide justification if single failure event is not considered in the analysis.

Response: The steam release analysis considered a single failure in a mitigating system as a failure in the AFW system. The MD AFW pump associated with the ruptured SG was assumed to fail such that no AFW flow from the motor-driven pump was delivered to the ruptured SG. Minimum AFW flow from the MD AFW pump associated with the intact SG was modeled. In addition, the TD AFW pump was not credited. Minimizing AFW flow increases the steam release through the MSSVs. Further, the analysis did not model the reverse flow check valves and considered all the steam release through the MSSVs on the ruptured SG steam line to be from the ruptured SG, maximizing the release of radioactivity from the ruptured SG.

4.0 References

1. EMF-2310(P)(A) Revision 1, *SRP Chapter 15 Non-LOCA Methodology for Pressurized Water Reactors*, Framatome ANP, May 2004.

ATTACHMENT 3

Response to NRC Reactor Systems Branch Request for Additional Information Regarding Extended Power Uprate License Amendment Request

AREVA NP
Application for Withholding Proprietary Information from Public Disclosure

(Cover page plus 3 pages)

AFFIDAVIT

COMMONWEALTH OF VIRGINIA)
) ss.
CITY OF LYNCHBURG)

1. My name is Gayle F. Elliott. I am Manager, Product Licensing, for AREVA NP Inc. (AREVA NP) and as such I am authorized to execute this Affidavit.

2. I am familiar with the criteria applied by AREVA NP to determine whether certain AREVA NP information is proprietary. I am familiar with the policies established by AREVA NP to ensure the proper application of these criteria.

3. I am familiar with the AREVA NP information contained in the report ANP-3019(P), Revision 0, entitled "St. Lucie Unit 1 EPU – Information to Support NRC Review of Steam Generator Tube Rupture," dated August 2011 and referred to herein as "Document." Information contained in this Document has been classified by AREVA NP as proprietary in accordance with the policies established by AREVA NP for the control and protection of proprietary and confidential information.

4. This Document contains information of a proprietary and confidential nature and is of the type customarily held in confidence by AREVA NP and not made available to the public. Based on my experience, I am aware that other companies regard information of the kind contained in this Document as proprietary and confidential.

5. This Document has been made available to the U.S. Nuclear Regulatory Commission in confidence with the request that the information contained in this Document be withheld from public disclosure. The request for withholding of proprietary information is made in accordance with 10 CFR 2.390. The information for which withholding from disclosure is

requested qualifies under 10 CFR 2.390(a)(4) "Trade secret and commercial or financial information."

6. The following criteria are customarily applied by AREVA NP to determine whether information should be classified as proprietary:

(a) The information reveals details of AREVA NP's research and development plans and programs or their results.

(b) Use of the information by a competitor would permit the competitor to significantly reduce its expenditures, in time or resources, to design, produce, or market a similar product or service.

(c) The information includes test data or analytical techniques concerning a process, methodology, or component, the application of which results in a competitive advantage for AREVA NP.

(d) The information reveals certain distinguishing aspects of a process, methodology, or component, the exclusive use of which provides a competitive advantage for AREVA NP in product optimization or marketability.

(e) The information is vital to a competitive advantage held by AREVA NP, would be helpful to competitors to AREVA NP, and would likely cause substantial harm to the competitive position of AREVA NP.

The information in the Document is considered proprietary for the reasons set forth in paragraphs 6(b) and 6(c) above.

7. In accordance with AREVA NP's policies governing the protection and control of information, proprietary information contained in this Document have been made available, on a limited basis, to others outside AREVA NP only as required and under suitable agreement providing for nondisclosure and limited use of the information.

8. AREVA NP policy requires that proprietary information be kept in a secured file or area and distributed on a need-to-know basis.

9. The foregoing statements are true and correct to the best of my knowledge, information, and belief.

SUBSCRIBED before me this 9th

day of August 2011.

Kathleen A. Bennett

Kathleen Ann Bennett
NOTARY PUBLIC, COMMONWEALTH OF VIRGINIA
MY COMMISSION EXPIRES: 8/31/15
Reg. # 110864

KATHLEEN ANN BENNETT
Notary Public
Commonwealth of Virginia
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My Commission Expires Aug 31, 2015