ArevaEPRDCPEm Resource

From: Tesfaye, Getachew
Sent: Tuesday, July 31, 2012 8:37 AM
To: ArevaEPRDCPEm Resource
Subject: Non-Proprietary Presentations and Affidavit for July 30th Mtg - RAI 403 and SGTR Event
Attachments: Affidavit RAI 403 Presentation (2).pdf; Non-Proprietary RAI 403 Meeting July 30 2012 _Redacted.pdf

Getachew,
Attached is AREVA NP's presentation for the Public Meeting on Monday afternoon. AREVA NP considers some of the material contained in the slides to be proprietary information. As required by 10 CFR 2.390, an affidavit is provided to support the withholding of the proprietary information from public disclosure. Proprietary and non-proprietary versions are attached.

Thanks,
Dennis

Dennis Williford, P.E.
U.S. EPR Design Certification Licensing Manager
AREVA NP Inc.
7207 IBM Drive, Mail Code CLT 2B
Charlotte, NC 28262
Phone: 704-805-2223
Email: Dennis.Williford@areva.com

Hearing Identifier: AREVA_EPR_DC_RAIs
Email Number: 3979

Mail Envelope Properties (0A64B42AAA8FD4418CE1EB5240A6FED19B3BDFEFD3)

Subject: Non-Proprietary Presentations and Affidavit for July 30th Mtg - RAI 403 and SGTR Event
Sent Date: 7/31/2012 8:37:10 AM
Received Date: 7/31/2012 8:37:14 AM
From: Tesfaye, Getachew

Created By: Getachew.Tesfaye@nrc.gov

Recipients:
"ArevaEPRDCPEm Resource" <ArevaEPRDCPEm.Resource@nrc.gov>
Tracking Status: None

Post Office: HQCLSTR02.nrc.gov

Files	**Size**	**Date & Time**
MESSAGE	678	7/31/2012 8:37:14 AM
Affidavit RAI 403 Presentation (2).pdf	119205	
Non-Proprietary RAI 403 Meeting July 30 2012_Redacted.pdf	993556	

Options
Priority: Standard
Return Notification: No
Reply Requested: No
Sensitivity: Normal
Expiration Date:
Recipients Received:

AFFIDAVIT

COMMONWEALTH OF VIRGINIA)
) ss.
COUNTY OF CAMPBELL)

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 "Public Meeting to Discuss Closure of U.S. EPR™ FSAR Open Items on RAI 403 and to Discuss Reanalysis of SGTR Event," 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 secrets 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 has 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 27th day of July 2012.

Kathleen A. Bennett
NOTARY PUBLIC, COMMONWEALTH OF VIRGINIA
MY COMMISSION EXPIRES: 8/31/2015
Reg. #110864

KATHLEEN ANN BENNETT
Notary Public
Commonwealth of Virginia
110864
My Commission Expires Aug 31, 2015

Public Meeting to Discuss Closure of U.S. EPR™ FSAR Open Items on RAI 403 and to Discuss Reanalysis of SGTR Event

Rockville, Maryland
July 30, 2012

EPR™ by AREVA

AREVA

Meeting Purpose and Background

- **RAI 403**
  - Review associated schedule for U.S. EPR FSAR open items for RAI 403
  - Confirm agreement with the NRC on the path to closure for U.S. EPR open items for RAI 403
  - Identify future NRC/AREVA interaction opportunities to support closure of RAI 403
- **Steam Generator Tube Rupture Reanalysis**
  - Describe revision to Steam Generator Tube Rupture Event (SGTR) analysis and impact on FSAR

Summary of Open Items for RAI 403

RAI	Question No.	Topic/Subject	Draft to NRC	Final to NRC
403	15.06.05-61	SBLOCA boron dilution - condensate	6/7/2013	7/30/2013
403	15.06.05-62	SBLOCA boron dilution – reboration of cross over pipe	6/7/2013	7/30/2013
403	15.06.05-63	SBLOCA boron dilution – PKL tests	6/7/2013	7/30/2013

Regulatory Basis – SBLOCA Boron Dilution – GSI-185

- **Applicable Regulations**
  - **10 CFR 50.46 – requirements for criteria, long term cooling is particularly pertinent**
  - **GDC 27 – control rod requirements to assure that the core can be cooled**
  - **GDC 28 – Requirements regarding reactivity insertion accidents not impacting the ability to cool the core**
  - **GDC 35 - ECCS requirements to enable the core to be cooled and ECCS requirements for a single failure**

Regulatory Basis – SBLOCA Boron Dilution – GSI-185

- **Standard Review Plan Section 15.6.5**
  - **"For a small break loss of coolant accident, the reactor systems reviews the potential for the addition of un-borated water into the core from the reactor coolant pump seals, and the potential for additional core damage caused by reactivity transients from the unborated water."**

Regulatory Basis – SBLOCA Boron Dilution – GSI-185

- **NRC closure of GSI-185 documented in a memorandum to Luis A. Reyes from C. J. Paperiellio, 'Closure of Generic Safety Issue 185, "Control of Recriticality Following Small-Break LOCAs in PWRs'", September 23, 2005.**
- **The memorandum states:**
  - **"Boron Dilution With Restart of Natural Circulation**
    - Under the most bounding assumption for the size of a diluted slug, and with realistically conservative treatment of mixing, calculations for a Framatome B&W reactor indicated a return to criticality with no fuel damage. Therefore, boron dilution with restart of natural circulation is not a significant event at all Westinghouse, Combustion Engineering, and Framatome B&W reactors."

Regulatory Basis – SBLOCA Boron Dilution – GSI-185

- The lowered loop seal B&W plant design with the steam generator at the same elevation as the reactor vessel bounded the accumulation of deborate
- Deborated water volumes used in NRC reactivity calculations
  - Westinghouse ~8.2 m^3
  - CE ~17.7 m^3
  - B&W ~42 m^3
- U.S. EPR 11 m^3
- Based on this information, the NRC conclusion in their resolution of GSI-185 is applicable to the U.S. EPR

Path to Closure

- **RAI 403, Question 15.06.05-61 – SBLOCA boron dilution - condensate**
  - **The staff requested that AREVA provide a mass balance accounting for the steam and condensate generated in accident conditions**
  - **The proposed approach to resolve this issue is addressed in the proprietary portion of the meeting**

Path to Closure

- **RAI 403, Question 15.06.05-62 – SBLOCA boron dilution - reboration of cross over pipe**
  - **The staff requested that AREVA explain the dynamics of reboration of the cross over pipe in any idle loop prior to restart during SBLOCA**
  - **The proposed approach to resolve this issue is addressed in the proprietary portion of the meeting**

Path to Closure

- **RAI 403, Question 15.06.05-63 – SBLOCA boron dilution - PKL tests**
  - **The staff requested that AREVA explain how the entire matrix of relevant tests conducted at PKL or other facilities validates the assumptions in the boron dilution analysis for the U.S. EPR.**
  - **The proposed approach to resolve this issue is addressed in the proprietary portion of the meeting**

U.S. EPR SGTR Event
Event Description & Acceptance Criteria

- **Steam Generator Tube Rupture (SGTR) Event**
  - Double-ended rupture of a single SG tube
  - Tube rupture postulated in the shortest SG tube, near the tube sheet location – to maximize break flow (smallest resistance)
  - Primary coolant from the Reactor Coolant System (RCS) begins to enter the secondary, driven by the pressure differential
  - The inventory, pressure and activity in the affected SG increase
- **SGTR Acceptance Criteria**
  - Classified as a Postulated Accident
  - Primary acceptance criteria is to maintain the radiological releases below the acceptance limits
  - A secondary criterion is to prevent overfill of the SG to exclude water entering the steam lines

U.S. EPR SGTR Event
Issues

- **U.S. EPR Steam Generator Tube Rupture (SGTR) Analysis**
  - **U.S. EPR DCD SGTR Analysis was completed in 2007**
- **Issues Identified with SGTR S-RELAP5 Modeling**
  1. Turbine Control Valve Modeling
  2. SGTR Overfill without LOOP
  3. SG Loss Coefficients
  - **Issues 1 & 3 applicable to S-RELAP5 Non-LOCA model, in general**
  - **Issue 2 specific to SGTR modeling and analysis**
- **Revision of U.S. EPR SGTR Analyses of Record (AOR)**
  - **Re-analyze the U.S. EPR SGTR event in light of AREVA Corrective Action Program WebCAPs**
- **FSAR Impact**
  - **Section 15.6.3 – SGTR Safety Analysis**
  - **Section 15.0.3 – SGTR Radiological Dose Analysis**

SBLOCA Inherent Boron Dilution RAI Set 403 Questions 61-63 Discussion

Lisa Gerken

Rockville, Maryland

July 30, 2012

EPR™ by AREVA

AREVA

RAI 403 Planned Response

- Describe the evolution of the inherent boron dilution event
- Outline previous submittals and interactions
- Discuss the RAIs and how AREVA's plan to address them

SBLOCA Inherent Boron Dilution Event Description

- **In a small break LOCA, following the loss of natural circulation (NC), decay heat is removed from the core by reflux condensation (RC) in the vertical U-tubes of the SGs**
  - The steam condensing on the hot side of the SG vertical U-tubes flows back through the SG inlet plenum and into the core
  - The steam condensing on the cold side of the SG vertical U-tubes down through the SG outlet plenum and into the loop seal
  - Since the steam from the core carries only a small fraction of boron, the condensate produced in the SGs is boron depleted creating a “deborated slug”
- **The primary pressure continues to decrease until the pumped safety injection exceeds the break flow and RCS begins to refill**
- **Following a restart of NC, the deborated slug is transported into the RPV potentially challenging core recriticality**

SBLOCA Inherent Boron Dilution Event Description

- **The inherent boron dilution event only occurs for a limited range of break sizes. The break size must be:**
  - Large enough to stop natural circulation
  - Small enough that RCS does not depressurize below the secondary such that a substantial RC phase can exist
  - Small enough that the RCS can be refilled and natural circulation can restart
- **Various mixing processes are involved that raise the concentration of the deborated slug**
  - Mixing prior to restart of single phase NC:
    - Liquid carryover from the SG inlet
    - Backflow from the cold legs
  - Mixing during transport:
    - Borated water in the cold legs, downcomer, and lower plenum
    - Mixing with the highly borated SI and EBS injection flows

SBLOCA Inherent Boron Dilution Event Description

- **The inherent boron dilution event is fundamentally characterized by:**
  - The generation of deborated condensate
  - The size and concentration of the deborated slug
  - The transport of the deborated slug to the core
- **The existence of a RC phase is necessary to generate significant condensate, but the actual size of the slug is not directly tied to the amount of condensate**
- **The size of the deborated slug is limited by plant geometry and the mixing processes before the restart of single-phase NC**
  - The slug size can be estimated from geometry and from the tests on SBLOCA boron dilution phenomena (e.g. PKL).
- **Tests (e.g. U of M, ROCOM) and CFD analyses demonstrate the high degree of mixing during transport which reborates the slug prior to reaching the core entrance**

SBLOCA Inherent Boron Dilution Previous Submittals and Interactions

- **U.S. EPR Final Safety Analysis Report, Tier 2, Chapter 15.6.5.4.2 "SBLOCA Boron Dilution"**
- **ANP-10288, Rev. 1 "U.S. EPR Post-LOCA Boron Precipitation and Boron Dilution Technical Report"**
- **RAI Set 167:**
  - Question 15.06.05-29: Assessment of total amount of condensate generated in each loop
  - Question 15.06.05-30: Availability, quantity, and distribution of ECCS relative to reboration
  - Question 15.06.05-31: Long-term cooling secondary response
  - Question 15.06.05-32: Sufficiency of break spectrum
  - Question 15.06.05-33: Adequacy of model for long-term core cooling of SBLOCA
  - Question 15.06.05-34: Criticality consequences related to a single crossover pipe volume
  - Question 15.06.05-36: Applicability of PKL tests to US EPR
  - Question 15.06.05-37: Extent of cold leg mixing; relevancy of OL3 CFD calculations to the US EPR
- **NRC Meeting on U.S. EPR FSAR Chapter 15 RAI 403 – July 15, 2010**

*Future revision commitment relative to RAI Set 403 Boron Precipitation responses

SBLOCA Inherent Boron Dilution
RAI 403, Question 15.06.05-61

BORON DILUTION - CONDENSATE AMOUNT AND LOCATION:

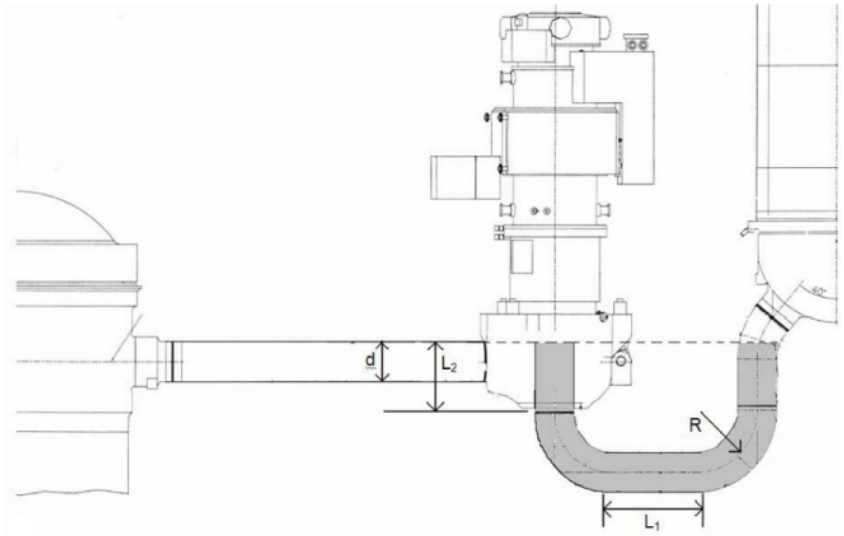
- In response to Question 15.06.05-29, the applicant did not provide an assessment of the amount of condensate generated by reflux condensation as was requested. Instead, predictions for the liquid content in control areas defined as “steam generator (SG) outlet plenum,” “loop crossover pipe,” and “cold leg” were presented. Provide a calculation of the amount of condensate generated by reflux condensation accounting for conditions with emergency feed water (EFW) supply present for two or more SGs.
- The staff requests a mass balance accounting for the steam generated in the core by decay heat, steam lost out the break, steam condensed in the SGs, condensate in countercurrent flow returned to the reactor vessel hot leg, condensate collected on the SG, loop crossover pipe, and cold leg, condensate lost out the break, and condensate transported to the vessel downcomer.
- The staff requests a description of situations involving stratified conditions in the cold leg and downcomer regions.

SBLOCA Inherent Boron Dilution
RAI 403, Question 15.06.05-61
Planned Response

BORON DILUTION - CONDENSATE AMOUNT AND LOCATION

SUMMARY OF PLANNED RESPONSE:

- **The volume of condensate is not equivalent to the volume of the deborated slug**
- **The size of the slug is more important than the total volume of condensate which gets distributed through the system**
- **The size of the slug is limited by the plant geometry**



SBLOCA Inherent Boron Dilution
RAI 403, Question 15.06.05-61
Planned Response

BORON DILUTION - CONDENSATE AMOUNT AND LOCATION

SUMMARY OF PLANNED RESPONSE:

- **A conservative estimation of the condensate during the reflux condensation will be provided**
- **In the long-term core cooling period following a small break LOCA, a wide variety of scenarios exist due, primarily, to:**
  - Break size
  - Equipment availability
  - Operator actions (e.g. realignment of EFW pumps, use of EBS, cooldown rates, etc.)
  - Operating ranges and assumptions
- **The combination of these variables represents a large number of scenarios with differences in:**
  - Timing of the loss and restart of natural circulation
  - Amount and location of condensate
  - RCS conditions throughout the duration of the condensation period
- **Therefore, there is no singular amount of condensate generated by reflux condensation accounting for conditions with EFW supply present for two or more SGs**

SBLOCA Inherent Boron Dilution
RAI 403, Question 15.06.05-61
Planned Response

BORON DILUTION - CONDENSATE AMOUNT AND LOCATION

SUMMARY OF PLANNED RESPONSE:

- **Estimates of condensate will be determined as:**
  - Condensate = Integral of (steam produced from decay heat – break flow) from loss of NC to restart of NC
- **S-RELAP5 will be used to analyze a limited spectrum of cases evaluating different break sizes and operating scenarios in order to**:
  - Approximate the time for the loss and restart of NC
  - Determine the steam and liquid loss out of the break flow during a given RC period
  - Evaluate distribution of condensate relative to SG upside and downsides
  - Evaluate the effects of the different scenarios of condensate generation and SG upside and downside distribution

SBLOCA Inherent Boron Dilution
RAI 403, Question 15.06.05-61
Planned Response

BORON DILUTION - STRATIFICATION

SUMMARY OF PLANNED RESPONSE:

- **The RAI response will discuss the locations of condensates and potential stratification. The stratification and mixing which occurs in the cold leg and downcomer regions will be supported technical resources such as:**
  - *"Potential for Inherent Boron Dilution During Small-Break LOCAs in PWRs" Brookhaven National Laboratory, BNL-NUREG-62261*
  - *Jacobsen, Sven Some Local Dilution Transients in a Pressurized Water Reactor Institute of Technology, Dept. of Mech Eng, S-581 83 Linkoping, Sweden*
  - *Kiger, K.T. and F. Gavelli "Boron Mixing in Complex Geometries: Flow Structure Details" Nuclear Engineering and Design 208 (2001) 67-85*
- **The response will also describe the mechanisms which occur during the RC phase and during the restart of NC which mix the stratified regions**

SBLOCA Inherent Boron Dilution
RAI 403, Question 15.06.05-62

BORON DILUTION - LIMITING SCENARIO AND REBORATION:

- As follow-up to response to question 15.06.05-30, demonstrate that deborated condensate accumulated in one or more loops (SG plena, loop seals, cold legs, downcomer) experiencing a complete or partial depravation of SI will not pose a recriticality threat to the U.S. EPR if transported towards the core due to natural circulation restart to identify and consider limiting conditions, assumptions, and scenarios in terms of condensate accumulation in individual loops and associated regions as well as transportation mechanisms involving possible restart in multiple primary loops.
- The dynamics of reboration of the crossover pipe in any idle loop prior to restart should be explained and justified. If the cold leg pipe break is below the elevation of the impeller discharge there does not appear to be a mechanism for backfill of the crossover pipe.
- Explain which of the postulated scenarios identified in the response to question 15.6.06.05-30 provides the greatest challenge to core recriticality and explain why.

SBLOCA Inherent Boron Dilution
RAI 403, Question 15.06.05-62
Planned Response

BORON DILUTION - LIMITING SCENARIO AND REBORATION

SUMMARY OF PLANNED RESPONSE:

- **The phenomena resulting in the limiting scenario are highly interconnected. For example,**
  - Loss of offsite power and EDG availability effect both ECCS and EFW availability
  - EBS availability affects the cooldown rate
- **Discussion of various ECCS and EFW scenarios**
  - Describe the ECCS, EBS, and EFW system configurations
- **A limiting scenario will be identified based the available systems and on a survey of S-RELAP5 results described for Q 61**

SBLOCA Inherent Boron Dilution RAI 403, Question 15.06.05-62 Planned Response

- The scenario-independent reboration mechanisms and aspects of the event which prevent the deborate from challenging core recriticality will be described. This includes:
  - Single loop restart of natural circulation. The restart of natural circulation is delayed in other loops
  - No accumulation of low-boron water in the SG inlet plena
  - The intermittent circulation and backflow into crossover pipe prior to stable natural circulation significantly raises the concentration of the slug
  - The boron concentration of the slug increases due to liquid carryover from the hot to cold side of the SG
  - Mixing during transport in the downcomer and lower plenum

SBLOCA Inherent Boron Dilution
RAI 403, Question 15.06.05-62
Planned Response

- Mixing during transport will occur in all scenarios and is a substantial reboration mechanism
- EPR-specific STAR-CD CFD analyses have been presented previously to demonstrate the reboration for a variety of slug sizes and scenarios
- To address concerns regarding the size of the deborate slug and the pre-transport mixing processes an additional sensitivity study was performed with a 20 m^3 (705 ft^3) slug

SBLOCA Inherent Boron Dilution
RAI 403, Question 15.06.05-62
Planned Response

SBLOCA Inherent Boron Dilution
RAI 403, Question 15.06.05-62
Planned Response

SBLOCA Inherent Boron Dilution
RAI 403, Question 15.06.05-62
Planned Response

- **Minimum concentration anywhere at the core inlet for various slug sizes**

SBLOCA Inherent Boron Dilution
RAI 403, Question 15.06.05-63

BORON DILUTION - TESTS AND CFD

- As follow-up to response to question 15.6.06.05-36, present the available experimental database pertaining to boron dilution relevant to the U.S. EPR boron dilution analysis. The staff considers limiting the database to Primärkreislauf-Versuchsanlage (PKL) Test F1.1 only, to be insufficient.
- Explain why experimental observations and in particular PKL findings can be applied to justify the assumptions and conditions used in the analysis of the U.S. EPR under critical LOCA conditions of interest.
- Explain how the entire matrix of relevant tests conducted at PKL or other facilities validates the assumptions in the boron dilution analysis including: (1) restart of natural circulation in only one loop at a time, (2) initial restart in a loop without SI, (3) justification of the boundary conditions assumed in the CFD mixing analysis of core inlet boron concentration and in particular substantiation of the slug injection rate deduced from the PKL experiments.

SBLOCA Inherent Boron Dilution
RAI 403, Question 15.06.05-63
Planned Response

BORON DILUTION - TESTS AND CFD

SUMMARY OF PLANNED RESPONSE:

- **RAI 15.06.05-36 Response Clarification:**
  - F1.1 test was provided as an example of the comparison between the test results and our S-RELAP5 analyses with similar conditions
  - Qualitative conclusions and applicability to U.S. were for the E and F series tests
- **Description of tests, analyses, and their results**
  - Refill processes and restart of natural circulation phenomena
    - PKL Transient Evolution Tests
    - PKL Separate Effects Test
  - Mixing processes of the dilute water slug in the cold-leg piping, the RPV downcomer, and the lower plenum after restoration of natural circulation
    - UPTF-TRAM,
    - ROCOM,
    - University of Maryland, etc.

SBLOCA Inherent Boron Dilution
RAI 403, Question 15.06.05-63
Planned Response

- **Star-CD CFD Justification and NC Restart Rate Comparison**
  - Analysis specific to a representative U.S. EPR, no geometric differences in components modeled
  - Injection concentration comparison
  - S-RELAP5 dilution parameter comparison

SBLOCA Inherent Boron Dilution Planned Response Summary

- **The inherent boron dilution event does not challenge recriticality due to:**
  - A small deborated slug size associated with the shallow U.S. EPR loop seal design
  - The reboration mechanisms which occur prior to the full restart of NC
  - The reboration in the cold legs, downcomer, and lower plenum prior to the reaching the core inlet
- **The responses to the three RAIs will:**
  - Provide an approximation of possible condensate amounts and its distribution
  - Identify a limiting scenario for core recriticality potential and explain the phenomena and reboration mechanisms which mitigate the criticality concern
  - Expand and justify the testing database
  - Describe the applicability of the STAR-CD analyses to the U.S. EPR

Interaction Opportunities

- **NRC/AREVA Interaction Opportunities**
  - **Potential Audit/Public Meeting** — **Mid-March 2013**

Reanalysis of SGTR Event

Parvez Salim
Rockville, Maryland
July 30, 2012

EPR™ by AREVA

AREVA

U.S. EPR SGTR Event
Event Description & Acceptance Criteria

- **Steam Generator Tube Rupture (SGTR) Event**
  - Double-ended rupture of a single SG tube
  - Tube rupture postulated in the shortest SG tube, near the tube sheet location – to maximize break flow (smallest resistance)
  - Primary coolant from the Reactor Coolant System (RCS) begins to enter the secondary, driven by the pressure differential
  - The inventory, pressure and activity in the affected SG increase
- **SGTR Acceptance Criteria**
  - Classified as a Postulated Accident
  - Primary acceptance criteria is to maintain the radiological releases below the acceptance limits
  - A secondary criterion is to prevent overfill of the SG to exclude water entering the steam lines

U.S. EPR SGTR Event
Issues

- **U.S. EPR Steam Generator Tube Rupture (SGTR) Analysis**
  - **U.S. EPR DCD SGTR Analysis was completed in 2007**
- **Issues Identified with SGTR S-RELAP5 Modeling**
  1. Turbine control valve modeling
  2. SGTR overfill without LOOP
  3. SG loss coefficients
  - **Issues 1 & 2 specific to SGTR modeling and analysis**
  - **Issue 3 applicable to S-RELAP5 models, in general**
- **Revision of U.S. EPR SGTR Analyses of Record (AOR)**
  - **Re-analyze the U.S. EPR SGTR event in light of AREVA Corrective Action Program WebCAPs**
- **FSAR Impact**
  - **Section 15.6.3 – SGTR Safety Analysis**
  - **Section 15.0.3 – SGTR Radiological Dose Analysis**

U.S. EPR SGTR Event
Extent of Conditions

- **Turbine Control Valve Modeling**
  - In the SGTR analysis, the discrepancy becomes noticeable only after extended period with no RT (~1000 seconds in the SGTR transient)
  - Only accompanied with primary-secondary energy balance upset – saturated RCS coolant replacing subcooled MFW
  - These situations not characteristic of other non-LOCA events
- **SGTR Overfill with No LOOP Assumption**
  - Specific to SGTR – other non-LOCA events not impacted
- **SG Loss Coefficient and Unphysical Circulation Pattern**
  - LOCA and Non-LOCA S-RELAP5 models potentially impacted
  - LOCA impact reported under 10 CFR 50.46
  - Other non-LOCA events being evaluated
  - FSAR not expected to be revised for the non-LOCA events

Issue #1
Turbine Control Valve Modeling

- Issue: Modeling of turbine valve to control steam demand – some of the behavior not physical
  - SGTR leak causes the TCV to close slightly to maintain the target flow rate
  - The valve adjustment causes the SG pressure and subsequently the steam flow to increase slightly – the process repeats
  - Consequently, the secondary pressure unphysically climbs until a Reactor Trip (RT) is invoked artificially
- The U.S. EPR SGTR analysis will be revised to correct the behavior
  - Modify S-RELAP5 TCV logic controlling the steam flow such that the valve behaves as it would in normal operation
- Radiological aspect of the analysis affected
  - Analysis w/o CVCS impacted more than the analysis with CVCS available

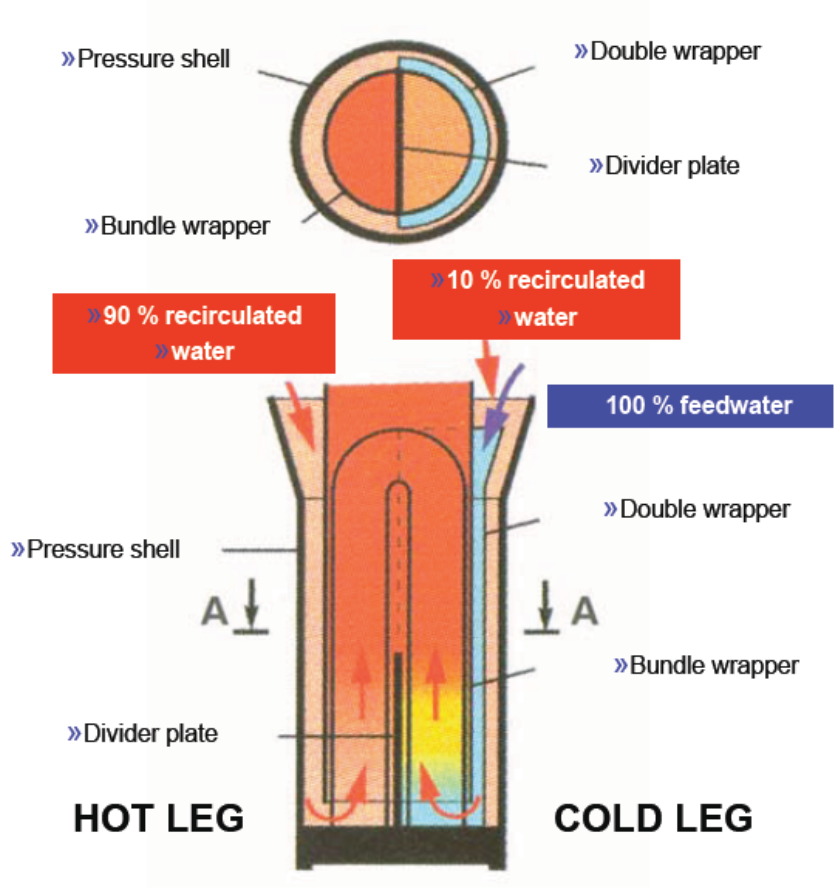
Issue #2
SGTR Overfill – No LOOP

- **Issue: The analysis of SGTR without LOOP for the overfill criterion was not performed, which could be more limiting than the analyzed LOOP case**
  - **With LOOP (no offsite power following RT):**
    - RCPs, MFW pumps and CVCS lost upon RT
    - EFW pumps loaded on energized diesel generator bus
    - EFW + break flow from RCS through broken tube are source of SG inventory expansion
  - **Without LOOP (offsite power available):**
    - RCPs, MFW pumps and CVCS continue to function
    - EFW pumps would not start
    - MFW + break flow from RCS are source of SG inventory expansion
    - Continued MFW would be more detrimental from SG overfill standpoint
- **The SGTR limiting overfill analysis to be performed with the assumption of no LOOP**
  - **Availability and continuous injection of MFW a significant contributor to the ruptured SG inventory and overfill**
  - **SGTR radiological analysis not impacted**

Issue #3
SG Loss Coefficients

- Issue: Non-physical post reactor trip SG circulation pattern in the U.S. EPR S-RELAP5 model
  - The U.S. EPR SG Economizer partitions the downcomer (DC) into two sides (see figures)
  - The issue pertains to non-physical circulation pattern through the bundle and DC partitions following RT and MFW termination
  - Due to this issue flow proceeds down the upside and up the downside on the cold-side of the SG tube/DC partition
- The modeling will be revised using time-dependent loss coefficients to eliminate the non-physical circulation pattern in the SG

U.S. EPR SG Economizer
Flow Distribution



At power, the MFW injects solely into the coldside (downside) of the SG tube bundle and there is a defined recirculation pattern in the SG in which more of the recirculated flow from the separator goes to the hot side.

SG Economizer Flow Pattern

U.S. EPR SGTR Event Issues
Expected Impact & Deliverables

- **Expected Impact**
  1. **Turbine Control Valve Modeling**
     - With issue correction, RT delayed until operator action at 30 minutes
     - Higher dose consequences expected
     - Dose limits not to exceed criteria
  2. **SGTR Overfill with No LOOP Assumption**
     - Reduction in overfill margin
     - Partial cooldown at 180 °F/hr to prevent overfill
  3. **SG Loss Coefficient and Unphysical Circulation Pattern**
     - Minor impact on radiological results expected
     - Overfill results not impacted
- **Deliverables**
  - **Revised SGTR limiting AOR**
  - **Updated FSAR**
    - Section 15.6.3 – SGTR Safety Analysis
    - Section 15.0.3 – SGTR Radiological Dose Analysis

U.S. EPR SGTR Event
AOR Results

Radiological Consequences

Radiological Consequences of SGTR Accident rem - Total Effective Dose Equivalent (TEDE)			
	Offsite Dose		Main Control Room Dose
	EAB (0.5 mile)	LPZ (1.5 miles)	
Pre-Incident Spike	1.1 (25)	0.3 (25)	0.3 (5)
Coincident Spike	0.7 (2.5)	0.5 (2.5)	0.6 (5)

Note: values in parentheses ( ) are the regulatory limits.

- **Above values are from the U.S. EPR FSAR Table 15.0-12**
- **The radiological releases are below 10 CFR 100 regulatory limit (or within limits of 10 CFR 50.67 for Alternate Source Term)**

Overfill Criteria

- **The liquid inventory in the affected SG does not increase to a point where overfill of the SG is a concern**
- **SG Wide Range Level in the affected SG <95%**

SGTR Reanalysis Schedule

- **Potential Audit/Public Meeting** — **Mid-March 2013**
- **Draft to NRC** — **May 6, 2013**
  - **Supplement to RAI 34**
- **Final to NRC** — **July 6, 2013**


AREVA