Tennessee Valley Authority
1101 Market Street, LP 3R
Chattanooga, Tennessee 37402-2801

R. M. Krich
Vice President
Nuclear Licensing

July 28, 2011

10 CFR 50.4

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Sequoyah Nuclear Plant, Units 1 and 2
Facility Operating License Nos. DPR-77 and DPR-79
NRC Docket Nos. 50-327 and 50-328

Subject: **Responses to Requests for Additional Information Regarding 10 CFR 50.46 Annual Report**

References:

1. TVA letter to NRC, "10 CFR 50.46 Annual Report," dated November 30, 2010
2. NRC letter to TVA, "Sequoyah Nuclear Plant, Units 1 and 2 - Request for Additional Information Regarding 10 CFR 50.46 Annual Report (TAC Nos. ME5168 and ME5169)," dated June 28, 2011

By letter dated November 30, 2010 (Reference 1), the Tennessee Valley Authority (TVA) submitted, in accordance with 10 CFR 50.46, "Acceptance Criteria for Emergency Core Cooling Systems for Light-Water Nuclear Power Reactors," the annual report of changes or errors discovered in the emergency core cooling system evaluation model for the Sequoyah Nuclear Plant (SQN), Units 1 and 2. In a letter dated June 28, 2011 (Reference 2), the NRC requested that additional information be provided regarding the 10 CFR 50.46 annual report for SQN, Units 1 and 2, within 30 days (i.e., by July 28, 2011). The enclosures to this letter provide the TVA responses to the NRC requests for additional information.

A002
NRR

Enclosures 1 and 2 to this letter contain information that AREVA NP considers to be proprietary in nature and subsequently, pursuant to 10 CFR 2.390, "Public inspections, exemptions, requests for withholding," paragraph (a)(4), it is requested that such information be withheld from public disclosure. Enclosure 5 to this letter provides the affidavit supporting this request. Enclosures 3 and 4 to this letter contain the redacted versions of the proprietary enclosures with the proprietary material removed, which are suitable for public disclosure.

There are no new commitments contained in this letter. If you have any questions, please contact Dan Green at 423-751-8423.

Respectfully,

JC Porter
for
R. M. Krich

Enclosures:

1. Responses to Requests for Additional Information Regarding Sequoyah Nuclear Plant, Units 1 and 2, 10 CFR 50.46 Annual Report (Proprietary Version)

2. Updated Sequoyah Nuclear Plant, Units 1 and 2, 10 CFR 50.46 Report (Proprietary Version)

3. Responses to Requests for Additional Information Regarding Sequoyah Nuclear Plant, Units 1 and 2, 10 CFR 50.46 Annual Report (Non-Proprietary Version)

4. Updated Sequoyah Nuclear Plant, Units 1 and 2, 10 CFR 50.46 Report (Non-Proprietary Version)

5. AREVA NP Affidavit

cc (Enclosures):

NRC Regional Administrator - Region II
NRC Senior Resident Inspector - Sequoyah Nuclear Plant

ENCLOSURE 3

RESPONSES TO REQUESTS FOR ADDITIONAL INFORMATION REGARDING SEQUOYAH NUCLEAR PLANT, UNITS 1 AND 2, 10 CFR 50.46 ANNUAL REPORT (NON-PROPRIETARY VERSION)

The following Request for Additional Information (RAI) responses address those RAIs as sent by the NRC to the Tennessee Valley Authority in "Sequoyah Nuclear Plant, Units 1 and 2 - Request for Additional Information Regarding 10 CFR 50.46 Annual Report (TAC Nos. ME5168 and ME5169)," dated June 28, 2011.

On November 30, 2010 (Agencywide Documents Access and Management System Accession No. ML103370242), Tennessee Valley Authority submitted, for Nuclear Regulatory Commission (NRC) review and evaluation, the annual report of changes or errors discovered in the emergency core cooling system evaluation model for Sequoyah Nuclear Plant, Units 1 and 2, as required under paragraph (a)(3)(ii) of Title 10 of the Code of Federal Regulations (10 CFR) Part 50, Section 50.46, "Acceptance Criteria for Emergency Core Cooling Systems for Light-Water Nuclear Power Reactors." In order to complete our evaluation, we need the following additional information:

RAI 1

With respect to the annual report covering the period until November 30, 2010, a summary of the information provides results from large break loss-of-coolant accident (LBLOCA) evaluation model and small break loss-of-coolant accident (SBLOCA) evaluation model, however, no specific detailed calculation information is given.

Please identify:

RAI 1(a)

(a) which specific criteria were used to select a reasonable bias on interphase friction at the steam generator tube sheet entrance;

Response

During the reflood phase of a LBLOCA, some of the water droplets entrained in the flow from the core region are vaporized in the steam generator tubes due to heat transfer from the hot secondary side of the steam generator. The vaporization of the water in the steam generator tubes increases the pressure difference between the break and the core, typically called "steam binding," which affects the rate of core flooding and Emergency Core Cooling System (ECCS) injection flow and consequently peak clad temperature (PCT). The amount of water entrained from the core region that reaches the steam generator tubes is influenced by the interphase friction in the region from the upper plenum to the tube inlet.

The AREVA Realistic LBLOCA analysis methodology used in the Sequoyah Nuclear Plant (SQN) LBLOCA analysis of record uses a bias on interphase friction at the steam generator tube sheet entrance to establish the magnitude of liquid entrainment in the steam generator tubes. As a quantitative determination of the uncertainty in interphase friction is not feasible, a bias is applied to establish a conservatively bounding value. The bias is established by comparing calculated results from the S-RELAP5 model of the Upper Plenum Test Facility (UPTF) with established test data (i.e., UPTF Tests 10B and 29B). The specific parameter measured in the UPTF tests and then compared to the S-RELAP5 model is the amount of water collected in the steam generator simulators (steam/water separator) which represents the integrated amount of water droplets entering the tube region. The magnitude of the bias is determined by adjusting the S-RELAP5 interphase drag multiplier "FIJ" at the tube inlet junctions until S-RELAP5 over-predicts the entrainment observed in UPTF Tests 10B and 29B by an arbitrary amount.

The value of "FIJ" was increased from [ ] to [ ] because the flow area in the S-RELAP5 model of the UPTF used in the benchmark work for UPTF Test 10B and Test 29B was discovered to be too small. When the corrected (larger) flow area was used in the S-RELAP5 model of the UPTF, "FIJ" needed to be increased to ensure S-RELAP5 would over-predict the amount of water retained in the steam generator tubes during a LBLOCA.

RAI 1(b)

(b) the available document for sensitivity study on the S-RELAP5 realistic LBLOCA multiplier "FIJ" to meet the bias criteria;

Response

[ ] This calculation is available for review in AREVA offices.

RAI 1(c)

(c) which approved methodologies are used for LBLOCA and SBLOCA evaluation; and

Response

The topical reports used for the LBLOCA and the SBLOCA evaluations are listed in the administrative section of the SQN Technical Specifications as approved Core Operating Limit Report methods.

3. For the LBLOCA evaluation, the method is EMF-2103(P)(A) Revision 0 with Transition Package as documented in ANP-2655P, Revision 001, which uses the S-RELAP5 code.

4. For the SBLOCA evaluation, the method is based on BAW-10168(P)(A) Revision 3, which uses the RELAP5/MOD2-B&W Version 27 code.

RAI 1(d)

(d) the reason why the results due to the errors show there are 12 degrees Fahrenheit (°F) peak cladding temperature (PCT) change for LBLOCA evaluation and 0°F PCT change for SBLOCA evaluation.

Response

In a SBLOCA event, depressurization of the RCS is much slower and break flows are less. The only time the interphase friction occurs in the hot legs and steam generator inlet plenums tube regions is during the reflux condensation period when the flow at the tube inlet is counter-current. The flow at the tube inlet is primarily controlled by counter-current limitations. For these conditions, RELAP5/Mod2-B&W is accurately benchmarked using a variety of tests in the AREVA SBLOCA documentation (refer to Volume II of BAW-10168(P)(A), Revision 3). Therefore, interphase friction and the amount of water retained in the steam generator tubes does not affect SBLOCA PCT results and the modeling of this phenomena is not part of the SBLOCA methodology.

RAI 2

Please provide the annual report including a detailed analysis.

Response

The 10 CFR 50.46 Annual Report for SQN, Units 1 and 2, submitted to NRC in the TVA letter, "10 CFR 50.46 Annual Report," dated November 30, 2010, has been updated to include the information provided in the TVA responses to the NRC RAIs. The updated 10 CFR 50.46 Annual Report is provided in Enclosure 2.

ENCLOSURE 4

UPDATED SEQUOYAH NUCLEAR PLANT, UNITS 1 AND 2, 10 CFR 50.46 REPORT (NON-PROPRIETARY VERSION)

(Originally submitted to NRC in TVA letter, "10 CFR 50.46 Annual Report," dated November 30, 2010. Revision bars have been used to identify changes.)

Estimated Effect on Limiting Analyses

The following is a summary of the limiting design basis accident (loss-of-coolant accident) analysis results established using the current Sequoyah Nuclear Plant (SQN) emergency core cooling system (ECCS) evaluation model. The licensing basis peak cladding temperature (PCT) was 1985 degrees Fahrenheit (F) as of November 30, 2009.

Large Break Loss of Coolant Accident (LB LOCA)

	PCT
Previous Licensing Basis PCT (November 30, 2009)	1985 degrees F
Steam Generator Tube Liquid Entrainment Model Error (See Description of Changes or Errors)	+ 12 degrees F
Updated Licensing Basis PCT	1997 degrees F
Net Change	+ 12 degrees F

Small Break Loss of Coolant Accident (SB LOCA)

	PCT
Previous Licensing Basis PCT (November 30, 2009)	1403 degrees F
Updated Licensing Basis PCT	1403 degrees F
Net Change	None

Description of Changes or Errors

STEAM GENERATOR TUBE LIQUID ENTRAINMENT MODELING ERROR

5. Background

During the reflood phase of a large break loss-of-coolant-accident (LBLOCA), some of the water droplets entrained in the flow from the core region are vaporized in the steam generator tubes due to heat transfer from the hot secondary side of the steam generator. The vaporization of the water in the steam generator tubes increases the pressure difference between the break and the core typically called "steam binding", which affects the rate of core flooding and Emergency Core Cooling System (ECCS) injection flow and consequently peak clad temperature (PCT). The amount of water entrained from the core region that reaches the steam generator tubes is influenced by the interphase friction in the region from the upper plenum to the tube inlet.

The AREVA Realistic LBLOCA analysis methodology used in the Sequoyah Nuclear Plant (SQN) LBLOCA analysis of record uses a bias on interphase friction at the steam generator tube sheet entrance to establish the magnitude of liquid entrainment in the steam generator tubes. As a quantitative determination of the uncertainty in interphase friction is not feasible, a bias is applied to establish a conservatively bounding value. The bias is established by comparing calculated results from the S-RELAP5 model of the Upper Plenum Test Facility (UPTF) with established test data (i.e., UPTF Tests 10B and 29B). The specific parameter measured in the UPTF tests and then compared to the S-RELAP5 model is the amount of water collected in the steam generator simulators (steam/water separator) which represents the integrated amount of water droplets entering the tube region. The magnitude of the bias is determined by adjusting the S-RELAP5 interphase drag multiplier "FIJ" at the tube inlet junctions until S-RELAP5 over-predicts the entrainment observed in UPTF Tests 10B and 29B by an arbitrary amount.

As documented in the AREVA NP Document E-2353-N90-59, "*Evaluation of Interfacial Drag Between Phases for UPTF and FLECHT-SEASET Tests,*" the amount of entrainment was determined by examining the S-RELAP5 computed integrated liquid mass flow and comparing with the mass that accumulated in the test steam/water separators. In computing the S-RELAP5 liquid mass flow, the model flow areas were smaller than required for an adequate assessment, yielding an artificially large calculated liquid entrainment prediction.

[ ]

6. Upper Plenum Test Facility

The UPTF was designed to simulate a four-loop 3900 MWt PWR primary system, and was intended to provide a full-scale simulation of thermal-hydraulic behavior in the primary system during the end-of-blowdown, refill, and reflood phases of an LBLOCA. In the UPTF the steam generators are replaced with steam/water separators and the pumps are simulated with pump simulators; the facility has no core, per se; entrainment during the reflood phase of a LOCA is simulated with steam and water injection. Simulation of the

UPTF tests with the S-RELAP5 code is described in some detail in Section 4.3.1.11 of the AREVA Realistic Large Break LOCA Evaluation Methodology (RLBLOCA EM), EMF-2103(P)(A) Revision 0.

6.1 UPTF Test 10 and Test 29

UPTF Test 10B and Test 29B were specifically designed to simulate upper core, upper plenum, and hot-leg fluid flow behavior during the reflood phase of a LBLOCA transient. These tests were analyzed to demonstrate the ability of S-RELAP5 to properly predict entrainment/ de-entrainment phenomena and to limit countercurrent flow in the upper plenum regions of a PWR during the LBLOCA reflood phase. Limiting liquid flow back into the core is important because it can provide a source of additional core cooling and reduces liquid carryout to the steam generators. Liquid carryout to the steam generators affects predicted steam binding caused by the liquid vaporization in the steam generators. Since the steam generator secondary pressures and temperatures are still near their initial operating values, increasing the liquid flow into the steam generator tubes increases the amount of flashing inside the tubes and leads to increased pressure drop between the core exit and break location. This effect, called steam binding, adversely impacts predicted PCT. Therefore, S-RELAP5 parameters controlling this entrainment require a bias to account for uncertainties in prediction of two-phase flow field phenomena.

UPTF Test 10B, Run 081, and 29B, Run 211/212, were separate effects tests that investigated core, upper plenum, hot leg and steam generator behavior during the reflood phase of a PWR LBLOCA with a cold-leg break. For all of these runs, the UPTF system was configured to simulate the reflood phase of a cold-leg break PWR LBLOCA. For these tests, the lower plenum and lower downcomer were filled with water to block steam flow directly from the core to the downcomer and cold legs. A mixture of steam and water was injected into the core simulator to simulate reflood steam generation and water entrainment.

The test configuration causes injected steam and entrained water to flow to the hot legs through the upper core support plate and upper plenum. From the hot legs, the steam/water mixture flowed into the steam generator simulators where water was separated from the mixture by cyclone separators. The separated water was stored and measured in holding tanks, while the steam (and any un-separated water) flowed onward through the pump simulators, intact cold legs, upper annulus and broken cold leg to the break.

6.2 S-RELAP5 Assessment with FIJ Multiplier set to [ ]

The S-RELAP5 parameter that controls entrainment is interphase friction. Interphase friction is widely variant when considering two-phase flow regimes in the hot leg, steam generator inlet plenum and steam generator tube sheet. As a result, determination of the uncertainty in interphase friction is not feasible. In the application of the AREVA RLBLOCA EM, S-RELAP5 models incorporate a conservative bias instead. The magnitude of the bias is determined by adjusting the interphase friction multiplier "FIJ" at the tube inlet junctions until S-RELAP5 over-predicts the entrainment observed in UPTF Tests 10B and 29B by an arbitrary amount.

In AREVA RLBLOCA EM, FIJ was set equal to [ ] to perform the calculation of the carryover to the steam/water separators in UPTF Test 10B (Run 081) and Test 29B (a combination of Runs 211 and 212). Figures 2-1 and 2-2 show the measured and calculated integrated mass accumulation in the steam/water separators in Tests 10B and 29B, respectively.

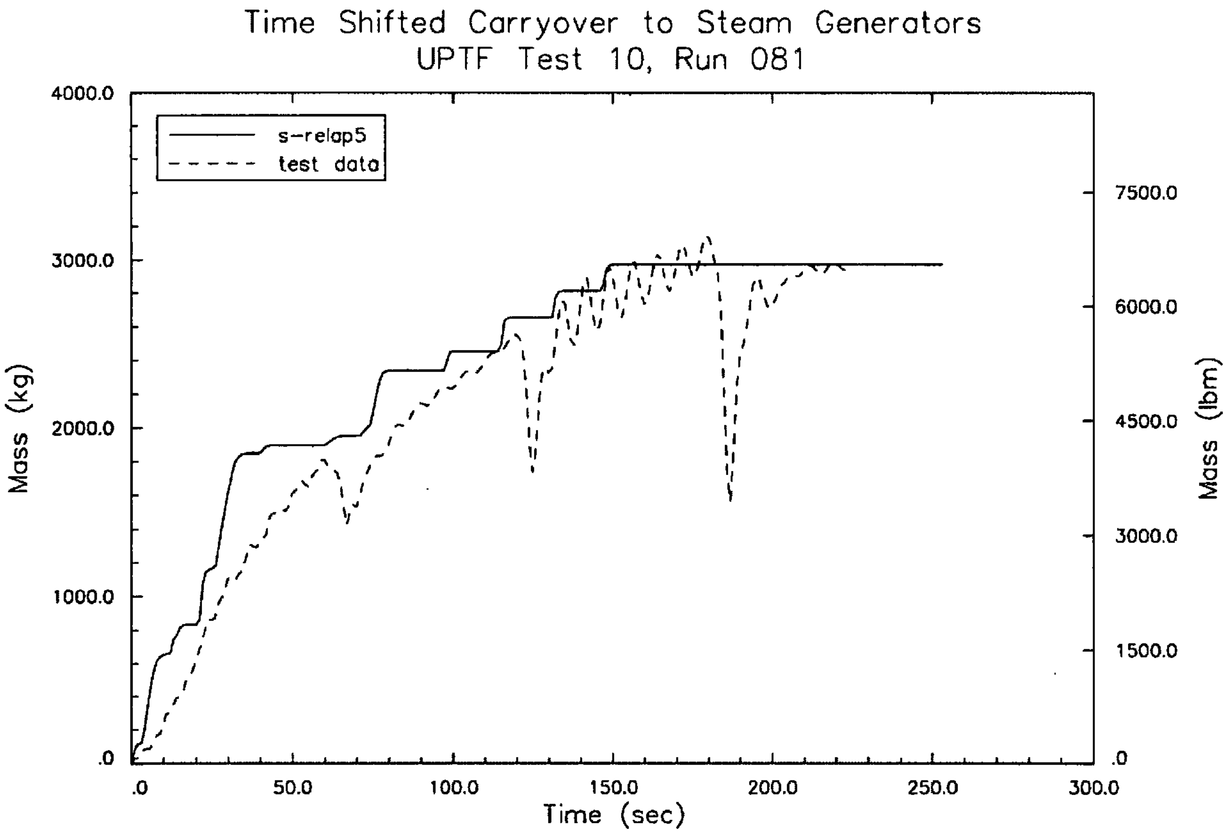

Figure 6-1: Carryover to Steam Generators UPTF Test 10 Run 081 Beyond 150 seconds

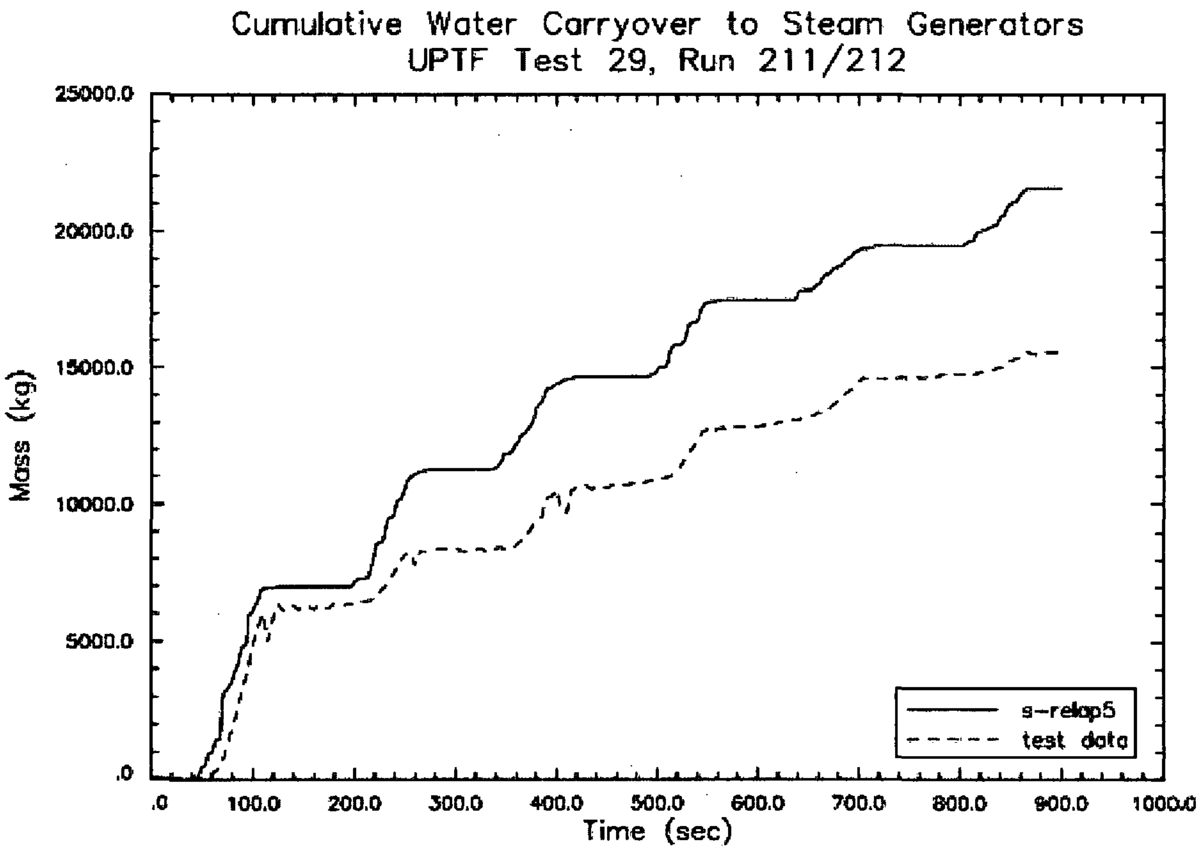

Figure 6-2: Cumulative Water Carryover to Steam Generators UPTF Test 29 Run 211/212

6.3 S-RELAP5 Assessment with FIJ Multiplier set to [ ]

In the revised S-RELAP5 calculations of these two tests, the junction area in the entrainment calculation has been corrected and a value of FIJ equal to [ ] is used. Figures 2-3 and 2-4 show the measured and calculated integrated mass accumulation in the steam/water separators in Tests 10B and 29B, respectively. It can be seen that, with this change, S-RELAP5 computes a conservative amount of entrainment in simulation of these tests.

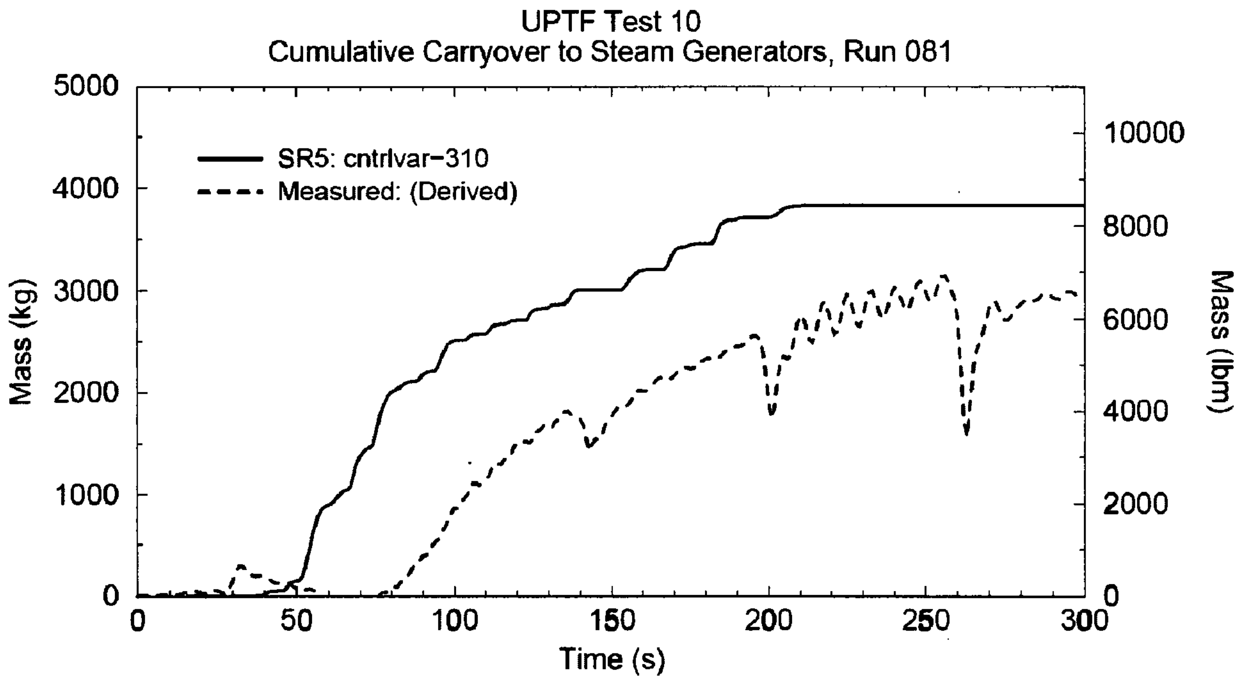

Figure 6-3: Cumulative Water Carryover to Steam Generators for UPTF Test 10 Run 081

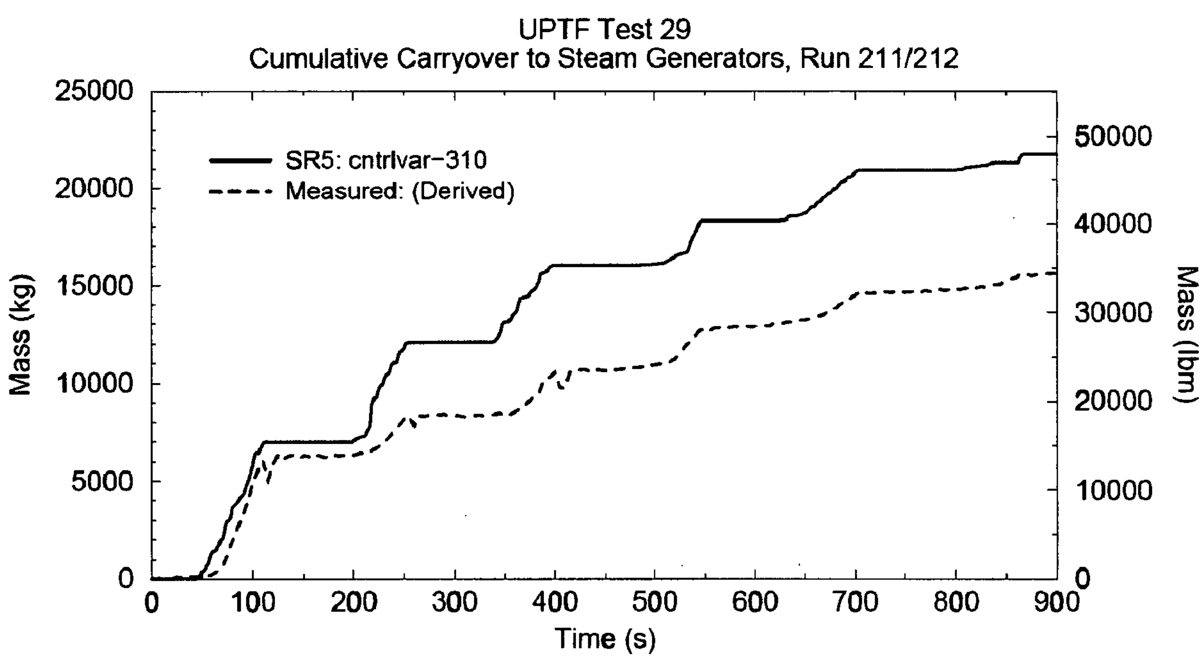

Figure 6-4: Cumulative Water Carryover to Steam Generators for UPTF Test 29 Run 211/212

Overall, the computed liquid carryover to the steam generators is calculated in an acceptable manner when the FIJ multiplier at the tube sheet inlet is set to [ ].

7. Small Break LOCA Considerations

In a Small Break LOCA (SBLOCA) event, depressurization of the RCS is much slower and break flows are less. The only time the interphase friction occurs in the hot legs and steam generator inlet plenums tube regions is during the reflux condensation period when the flow at the tube inlet is counter-current. The flow at the tube inlet is primarily controlled by counter-current limitations (CCFL). For these conditions, RELAP5/Mod2-B&W is accurately benchmarked using a variety of tests in the AREVA SBLOCA documentation (refer to Volume II of BAW-10168(P)(A), Revision 03). Therefore there is no need to adjust the interphase drag models for SBLOCA applications.

8. Conclusion

The interphase friction in the steam generator tube inlet junctions is adjusted in S-RELAP5 RLBLOCA models by adjusting the input parameter FIJ. The value of FIJ was increased from **[ ]** to **[ ]**. The primary reason for the change was to correct the flow area input in the S-RELAP5 UPTF benchmark model that was too small. The areas were corrected and the benchmark runs for UPTF Test 10B and Test 29B, originally reported in the RLBLOCA EM, were repeated. The input parameter related to the simulation of interphase frictional effects, FIJ, required an increase to ensure S-RELAP5 conservatively over-predicts the amount of water retained in the steam generator tubes during a LBLOCA.

There is no need to adjust the interphase friction models used in the analysis of SBLOCAs, since the flow phenomena in SBLOCA is completely different from that in LBLOCA. Models and benchmarks for SBLOCA applications are completely independent of those used for LBLOCA analyses. No errors have been noted by AREVA in the simulation of counter-current flow occurring in the progression of a SBLOCA.

The topical reports used for the LBLOCA and SBLOCA evaluations are listed in the administrative section of the SQN Technical Specifications as approved Core Operating Limits Report methods:

3. LBLOCA is EMF-2103(P)(A) Revision 0 with Transition Package as documented in ANP-2655P Revision 001 which uses the S-RELAP5 code and

4. SBLOCA is based on BAW-10168(P)(A) Revision 3, which uses RELAP5/MOD2-B&W Version 27.

[There is no penalty to the SBLOCA results.]

ENCLOSURE 5

AREVA NP AFFIDAVIT

Attached is the affidavit supporting the request to withhold proprietary information (included in Enclosures 1 and 2) from the public.

AFFIDAVIT

STATE OF WASHINGTON)
) ss.
COUNTY OF BENTON)

1. My name is Alan B. Meginnis. I am Manager, Product Licensing, for AREVA NP Inc. 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 Enclosure 1 and Enclosure 2 of the TVA Letter to NRC entitled, "Responses to Requests for Additional Information Regarding 10 CFR 50.46 Annual Report," dated July 28, 2011, referred to herein as "Documents." Information contained in these Documents 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. These Documents contain information of a proprietary and confidential nature and are 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 these Documents as proprietary and confidential.

5. These Documents have been made available to the U.S. Nuclear Regulatory Commission in confidence with the request that the information contained in these Documents 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 these Documents is considered proprietary for the reasons set forth in paragraphs 6(b), 6(d) and 6(e) above.

7. In accordance with AREVA NP's policies governing the protection and control of information, proprietary information contained in these Documents 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 28th day of July, 2011.

Mary A. Heilman
NOTARY PUBLIC, STATE OF WASHINGTON
MY COMMISSION EXPIRES: 6/9/12

MARY ANNE HEILMAN
COMMISSION EXPIRES
NOTARY
PUBLIC
06-09-12
STATE OF WASHINGTON