ArevaEPRDCPEm Resource

From: BRYAN Martin (EXT) [Martin.Bryan.ext@areva.com]
Sent: Wednesday, June 09, 2010 5:32 PM
To: Tesfaye, Getachew
Cc: DELANO Karen V (AREVA NP INC); ROMINE Judy (AREVA NP INC); BENNETT Kathy A (OFR) (AREVA NP INC); GUCWA Len T (EXT)
Subject: Response to U.S. EPR Design Certification Application RAI No. 368, FSAR Ch 6, Supplement 1, Part 1 of 5
Attachments: RAI 368 Supplement 1 US EPR DC Part 1 of 5.pdf

Getachew,

AREVA NP Inc. (AREVA NP) provided responses to 3 of the 23 questions in RAI No. 368 on April 19, 2010. Because of the file size, AREVA NP is providing a technically correct and complete response to 6 of the remaining 20 questions in 5 parts. The 5 files are designated as "RAI 368 Supplement 1 US EPR DC Part X of 5.pdf," where "X" is one of the five parts. The first file, part 1 of 5, contains the response to 5 of the 6 questions, and the remaining question 06.02.01-77 is transmitted in parts 2 through 5.

Attached is file, "RAI 368 Supplement 1 US EPR DC Part 1 of 5.pdf."

The following table indicates the respective pages in the response document, "RAI 368 Supplement 1 Response US EPR DC Part 1 of 5.pdf," that contain AREVA NP's response to the subject questions.

Question #	Start Page	End Page
RAI 368 — 06.02.01-58	2	9
RAI 368 — 06.02.01-59	10	13
RAI 368 — 06.02.01-60	14	14
RAI 368 — 06.02.01-64	15	15
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The schedule for a technically correct and complete response to the remaining questions is unchanged and is provided below:

Question #	Response Date
RAI 368 — 06.02.01-61	July 8, 2010
RAI 368 — 06.02.01-62	August 5, 2010
RAI 368 — 06.02.01-63	July 8, 2010
RAI 368 — 06.02.01-66	August 5, 2010
RAI 368 — 06.02.01-67	August 5, 2010
RAI 368 — 06.02.01-68	August 5, 2010
RAI 368 — 06.02.01-69	August 5, 2010
RAI 368 — 06.02.01-70	July 8, 2010
RAI 368 — 06.02.01-71	July 8, 2010
RAI 368 — 06.02.01-73	July 8, 2010
RAI 368 — 06.02.01-76	July 8, 2010
RAI 368 — 06.02.01-78	July 8, 2010
RAI 368 — 06.02.01-80	July 8, 2010

RAI 368 — 06.02.01-81	July 8, 2010

Sincerely,

Martin (Marty) C. Bryan
U.S. EPR Design Certification Licensing Manager
AREVA NP Inc.
Tel: (434) 832-3016
702 561-3528 cell
Martin.Bryan.ext@areva.com

From: WELLS Russell D (AREVA NP INC)
Sent: Monday, April 19, 2010 6:17 PM
To: 'Getachew Tesfaye'
Cc: BRYAN Martin (EXT); BENNETT Kathy A (OFR) (AREVA NP INC); DELANO Karen V (AREVA NP INC)
Subject: Response to U.S. EPR Design Certification Application RAI No. 368, FSAR Ch 6

Getachew,

Attached please find AREVA NP Inc.'s response to the subject request for additional information (RAI). The attached file, "RAI 368 Response US EPR DC.pdf," provides technically correct and complete responses to 3 of the 23 questions.

The following table indicates the respective pages in the response document, "RAI 368 Response US EPR DC.pdf," that contain AREVA NP's response to the subject questions.

Question #	Start Page	End Page
RAI 368 — 06.02.01-58	2	2
RAI 368 — 06.02.01-59	3	3
RAI 368 — 06.02.01-60	4	4
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RAI 368 — 06.02.01-74	19	19
RAI 368 — 06.02.01-75	20	20
RAI 368 — 06.02.01-76	21	21
RAI 368 — 06.02.01-77	22	22
RAI 368 — 06.02.01-78	23	23
RAI 368 — 06.02.01-80	24	24
RAI 368 — 06.02.01-81	25	25

A complete answer is not provided for 20 of the 23 questions. The schedule for a technically correct and complete response to these questions is provided below. Some of the response dates are subject to change based on anticipated feedback from the NRC staff regarding prioritization of responses. AREVA NP plans to discuss the response schedule with the NRC staff during an April 30, 2010, meeting.

Question #	Response Date
RAI 368 — 06.02.01-58	June 9, 2010
RAI 368 — 06.02.01-59	June 9, 2010
RAI 368 — 06.02.01-60	June 9, 2010
RAI 368 — 06.02.01-61	July 8, 2010
RAI 368 — 06.02.01-62	August 5, 2010
RAI 368 — 06.02.01-63	July 8, 2010
RAI 368 — 06.02.01-64	July 8, 2010
RAI 368 — 06.02.01-65	June 9, 2010
RAI 368 — 06.02.01-66	August 5, 2010
RAI 368 — 06.02.01-67	August 5, 2010
RAI 368 — 06.02.01-68	August 5, 2010
RAI 368 — 06.02.01-69	August 5, 2010
RAI 368 — 06.02.01-70	July 8, 2010
RAI 368 — 06.02.01-71	July 8, 2010
RAI 368 — 06.02.01-73	July 8, 2010
RAI 368 — 06.02.01-76	July 8, 2010
RAI 368 — 06.02.01-77	June 9, 2010
RAI 368 — 06.02.01-78	July 8, 2010
RAI 368 — 06.02.01-80	July 8, 2010
RAI 368 — 06.02.01-81	July 8, 2010

Sincerely,

(Russ Wells on behalf of)
Martin (Marty) C. Bryan
Licensing Advisory Engineer
AREVA NP Inc.
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From: Tesfaye, Getachew [mailto:Getachew.Tesfaye@nrc.gov]
Sent: Friday, March 19, 2010 4:08 PM
To: ZZ-DL-A-USEPR-DL
Cc: Jensen, Walton; Jackson, Christopher; Snodderly, Michael; Carneal, Jason; Colaccino, Joseph; ArevaEPRDCPEm Resource
Subject: U.S. EPR Design Certification Application RAI No. 368 (4344), FSARCh. 6

Attached please find the subject requests for additional information (RAI). A draft of the RAI was provided to you on February 9, 2010, and discussed with your staff on March 4, 2010. Drat RAI Question 06.02.01-79 was deleted, and Draft RAI Questions 06.02.01-61, 06.02.01-72, 06.02.01-73, and 06.02.01-78 were modified as a result of that discussion. The schedule we have established for review of your application assumes technically correct and complete responses within 30 days of receipt of RAIs. For any RAIs that cannot be answered within 30 days, it is expected that a date for receipt of this information will be provided to the staff within the 30 day period so that the staff can assess how this information will impact the published schedule.

Thanks,
Getachew Tesfaye
Sr. Project Manager
NRO/DNRL/NARP
(301) 415-3361

Hearing Identifier: AREVA_EPR_DC_RAIs
Email Number: 1525

Mail Envelope Properties (BC417D9255991046A37DD56CF597DB7106765E1E)

Subject: Response to U.S. EPR Design Certification Application RAI No. 368, FSAR Ch 6, Supplement 1, Part 1 of 5
Sent Date: 6/9/2010 5:32:25 PM
Received Date: 6/9/2010 5:32:45 PM
From: BRYAN Martin (EXT)

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Files	**Size**	**Date & Time**
MESSAGE	6368	6/9/2010 5:32:45 PM
RAI 368 Supplement 1 US EPR DC Part 1 of 5.pdf		164543

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

Response to

Request for Additional Information No. 368, Supplement 1

3/19/2010

U. S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 06.02.01 - Containment Functional Design
Application Section: 06.02.01

QUESTIONS for Containment and Ventilation Branch 1 (AP1000/EPR Projects) (SPCV)

Question 06.02.01-58:

From ANP-10299P Rev. 2 Table 12-21, the staff notes that several of the significant pie groups were not scaled well between the US-EPR containment and HDR containment test ISP-23 HDR/T31.5. For those pie groups which were found to have a high or medium significance and a high or medium distortion between US-EPR and HDR, provide justification that the US-EPR GOTHIC containment model is adequately representing the phenomena represented by these pie groups.

Response to Question 06.02.01-58:

Tables 06.02.01-58-1 summarizes the Π-groups, which have a high (H) or medium (M) significant distortion between the U.S. EPR containment and the HeissDamph Reaktor (HDR) test facility for the three phases following a large break loss of coolant accident (LBLOCA) scenario. Justifications for these distortions are discussed as follows:

1. Equipment Room/Accessible Space Mass & Energy Distortions.

   Pi-groups $\prod_{2,1}$ and $\prod_{2,9}$, represent the change in equipment room (ER) gas mass and pressure ratios (i.e., the forcing functions due to break flow), respectively. Distortions are attributed to lower initial break back-pressure (1160 psia) and smaller break size (0.11 ft^2) in the HDR test (i.e., a lower forcing function). The relatively small break flow indicated that the HDR test has a lower reference total steam mass and energy during the blowdown phase (i.e., the HDR has a reduced forcing function), making this the primary cause for most of the high and medium ranked distortions. The homogeneous equilibrium model (HEM) critical flow model was used in the GOTHIC analysis, which is conservative because it over-predicts the break mass flow rate.

   Pi-groups $\prod_{2,2}$, $\prod_{2,3}$, $\prod_{2,6}$, $\prod_{7,3}$, and $\prod_{7,7}$ represent gas or steam mass ratios due to expansion flows between the ER to accessible space (AS) ($\prod_{2,2}$ and $\prod_{2,6}$ are in the inflow or forward direction and $\prod_{2,6}$ is in the outflow or reverse direction). Because of the differences in the forcing function, some distortions in scale are expected. A perfect scale is not required to validate GOTHIC for the US EPR containment because gas expansion is related to the ideal gas laws (Pv=RT) in Technical Report ANP-10299P, Rev. 2, Section 12.4.6.

   Pi-groups $\prod_{2,11}$, $\prod_{2,12,}$ $\prod_{7,11}$, $\prod_{7,13}$, and $\prod_{7,14}$, represent the change in ER and AS pressure ratios due to wall convective heat transfer rates, which include free convection and condensation. Distortions occur because of a larger surface area to volume ratio in the HDR and the lack of a steam source. Because the diffusion layer model (DLM) option was used in GOTHIC, wall heat transfer rate is not affected by scale. The absence of a continuous steam source as the result of the lack of decay heat within the HDR test was the primary source of the distortions when compared to the U.S. EPR data. A more detailed explanation of the DLM model is provided at the end of this section.

   Pi-groups $\prod_{5,1}$ and $\prod_{6,1}$ represent a change in wall temperature ratios in ER and AS internal structure, respectively, due to wall surface heat transfer. Distortions are attributed to the larger surface area to volume ratios in the ER and AS of HDR. Wall heat transfer coefficients are not affected by scale because of the DLM option.

   In GOTHIC, a convective heat transfer rate at the wall surface is determined by the DLM. The DLM calculates the condensation rate and sensible heat transfer rate using heat/mass transfer analogies (Reference 1). The DML implementation includes formation of mist in the boundary layer and heat and mass transfer enhancement due to roughness of the condensate film. The model is applicable to the full range of steam gas mixtures in free and forced convection. The DML theory demonstrates that condensation on large vertical surfaces is independent of the surface height (Reference 2), making it applicable to the U.S. EPR GOTHIC model regardless of the finding of the scaling analysis.

2. ER-AS Recirculation Mass Flow Distortions (Momentum Components).

   Pi-groups $\prod_{11,1}$ and $\prod_{11,4}$ represent the change in recirculation mass flow ratios caused by pressure driving head between the ER and the AS. Pi-Groups $\prod_{11,2}$, and $\prod_{11,5}$ represent the changes in recirculation mass flow ratios due to frictional and form pressure losses, and Pi-Groups $\prod_{11,3}$ and $\prod_{11,6}$ represent the change in recirculation mass flow ratios due to density head between the ER and AS.

   Distortions in these Pi-groups are attributed to shorter flow path length and smaller open areas between the ER and the AS compartments inside the HDR containment than compared with the U.S. EPR containment. In GOTHIC, the momentum source terms, such as friction and form losses, are solved based on first principle, where the loss coefficients from the laminar to turbulent flow regimes are determined using standard, non-dimensional, empirical correlations.

   GOTHIC uses the two-equation k–ε model (Reference 3), which solves the partial differential equations that model the transport of effective parameters for calculating local turbulence, the velocity and the length scale. This model relies on empirically-determined coefficients to close the solutions. The k–ε model is only reliable in the range of problems where the empirical coefficients have been verified (Reference 4).

   In order to establish the validity of the empirical correlations used for the LBLOCA scenario, GOTHIC benchmark tests against the Battelle-Frankfurt Model Containment (BFMC) (Reference 5) and PANDA (ISP-42) (Reference 6) test data. These tests show reasonable agreement in predicting transport of steam/non-condensable gas mixture in separate compartments inside containment following a LBLOCA. The method for the momentum equation for gas recirculation between the ER and the AS regions of the U.S. EPR containment in the GOTHIC model are valid.

3. ER & AS Wall Structure Energy Distortions.

   Pi-groups $\prod_{5,1}$ and $\prod_{6,1}$ represent the change in wall temperature ratios in the ER and the AS internal wall structures, respectively, due to convective heat transfer. Because the DML option was used in the GOTHIC analysis, these distortions were not affected by scale as explained in the previous section.

4. Validation of GOTHIC Model Capabilities.

   Extensive GOTHIC benchmark tests have been performed against small-scale test facilities over a wide range of post-loss of coolant accident (LOCA) conditions (Reference 4). Table 06.02.01-58-2 lists the GOTHIC model validation test matrix against a set of integral test facilities. Results from these benchmark tests demonstrate that GOTHIC is capable of predicting the behaviors inside a U.S. EPR containment following a LBLOCA.

References for Question 06.02.01-58:

1. NAI, “GOTHIC Containment Analysis Package Technical Manual,” V. 7.2b(QA), NAI 8907-06 Rev 17, March 2009.

2. Peterson, P. F., Schrock, V.E., Kageyama T., “Diffusion Layer Theory for Turbulent Vapor Condensation with Noncondensable Gases,” ASME Journal of Heat Transfer, Vol. 115, pp 998-1003, 1993.
3. Analytis, G. Th., “Implementation of the renormalization group (RNG) k–" turbulence model in GOTHIC/6.lb: solution methods and assessment,” Annals of Nuclear Energy 30 (2003) 349–387.
4. NAI, “GOTHIC Containment Analysis Package Qualification Report,” V. 7.2b(QA), NAI 8907-09 Rev 10, March 2009.
5. Investigation of the Phenomena Occurring within a Multi-Compartment Containment after Rupture of the Primary Cooling Circuit in Water-Cooled Reactors, Technischer Bericht BF-RS 50-32-D1, Battelle-Institut e.V., 6000 Frankfurt am Main 90, Am Romerhof 35, Postfach 900160, March, 1977, (German with English summary).
6. Andreani, M., et al., “On the application of field codes to the analysis of gas mixing in large volumes: case studies using CFX and GOTHIC,” Annals of Nuclear Energy 30 (2003) 685–714.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Table 06.02.01-58—HDR PI-Groups High and Medium Distortion Justification Summary (2 Sheets)

Π	Physical Meaning	Distortion (Blowdown / Pre- / Post-HL Injection)	Justifications
$\Pi_{2,1}$	Change in gas mass ratio due to break flow from RCS.	H / M / n.a.	-HEM critical flow model is well known. -GOTHIC peak blowdown pressure is well benchmarked. -HDR lacks steam mass source term (lower forcing function).
$\Pi_{2,2}$	Change in gas mass ratio due to convective outflow to Accessible Space.	H / H / n.a.	-HDR lacks steam mass source term. -Transport of gas mass governed by ideal gas law. -Relationship is not affected by scale.
$\Pi_{2,3}$	Change in gas mass ratio due to convective inflow from Accessible Space.	H / L / n.a.	Same as $\Pi_{2,2}$
$\Pi_{2,6}$	Change in steam mass ratio due to convective outflow to Accessible Space.	H / H / L	Same as $\Pi_{2,2}$
$\Pi_{2,9}$	Change in pressure ratio due to break flow.	M / M / n.a.	Same as $\Pi_{2,1}$
$\Pi_{2,11}$	Change in pressure ratio due to wall convective heat transfer.	M / L / L	-Wall heat transfer rate is conduction limited. -GOTHIC wall film heat transfer rate is based on non-dimensional DLM.
$\Pi_{2,12}$	Change in pressure ratio due to convective outflow to Accessible Space.	H / H / L	Same as $\Pi_{2,9}$
$\Pi_{7,3}$	Change in gas mass ratio due to internal structure condensation mass flow.	L / M / n.a.	Same as $\Pi_{2,11}$
$\Pi_{7,7}$	Change in steam mass ratio due to internal structure condensation mass flow.	L / M / n.a.	Same as $\Pi_{2,11}$
$\Pi_{7,11}$	Change in pressure ratio due to internal structure condensation mass flow.	L / M / n.a.	Same as $\Pi_{2,11}$
$\Pi_{7,13}$	Change in pressure ratio due to internal wall conduction heat transfer rate.	L / L / H	Same as $\Pi_{2,11}$
$\Pi_{7,14}$	Change in pressure ratio due to containment wall conduction heat transfer rate.	L / M / M	Same as $\Pi_{2,11}$
$\Pi_{11,1}$	Change in mass flow ratio due to pressure driving force between ER and AS.	H / L / n.a.	-Distortion is from flow path length between ER and AS.

Table 06.02.01-58—HDR PI-Groups High and Medium Distortion Justification Summary (2 Sheets)

$\prod$	Physical Meaning	Distortion (Blowdown / Pre- / Post-HL Injection)	Justifications
$\prod_{11,2}$	Change in mass out-flow ratio due to form and friction pressure losses.	M / M / n.a.	-Distortion is from flow area and length between ER and AS.
$\prod_{11,3}$	Change in mass out-flow ratio due to gravity driving force between ER and AS.	M / H / n.a.	-Distortion is from vertical length between ER and AS.
$\prod_{11,4}$	Change in mass in-flow ratio due to pressure driving force between AS and ER.	H / M / n.a.	Same as $\prod_{11,1}$
$\prod_{11,5}$	Change in mass in-flow ratio due to form and friction pressure losses.	H / M / n.a.	Same as $\prod_{11,2}$
$\prod_{11,6}$	Change in mass in-flow ratio due to gravity driving force between ER and AS.	L / M / n.a.	Same as $\prod_{11,3}$
$\prod_{5,1}$	Change in wall temperature ratio in ER structure due to wall surface heat transfer.	H / H / L	-GOTHIC wall surface heat transfer model (DLM) is non-dimensional.
$\prod_{6,1}$	Change in wall temperature ratio in AS structure due to wall surface heat transfer.	H / M / L	Same as $\prod_{5,1}$

Table 06.02.01-58-2—GOTHIC Model Validation Integral Test Matrix (Reference 4)
(3 Sheets)

	Phenomenon/GOTHIC Model													
Integral Test	Drop Entrainment	Drop Deposition	Drop Settling	Drop Breakup	Drop Evaporation	Drop Condensation	Drop Agglomeration	Mist Generation	Mist Depletion	Pressure Drop / Single Phase	Pressure Drop / Bubbly Flow	Pressure Drop / Film-Drop Flow	Pressure Drop / Stratified Flow	Pressure Drop / Slug Flow
FLECHT SEASET Natural Circulation Tests										x	x	x	x	
CVTR Simulated DBA Tests		x	x		x	x		x	x					
Marviken Full Scale Containment Tests	x	x	x		x		x			X	X	X		X
Battelle-Frankfurt Containment Tests	x	x	x		x		x	x	x	x		x		
HEDL Hydrogen Mixing Tests								x	x					
HDR Full Scale Containment Tests		x	x		x		x	x	x	x		x		
NUPEC Tests		x	x		x	x								
PRV Tests		X	X		X									X
TOSQAN								x						
MISTRA								x						

Table 06.02.01-58-2—GOTHIC Model Validation Integral Test Matrix (Reference 4) (3 Sheets)

	Phenomenon/GOTHIC Model														
Integral Test	Buoyancy Induced Stratification	Flashing	Boiling Heat Transfer	Natural Convection	Forced Convection	Mixed Convection	Thermal Conduction in Solids	Condensation on Walls	Pool boiling	Pool Surface Evaporation	Heat/Mass Transfer in Superheated Steam	Bubble Condensation	Forced Circulation	Natural Circulation	Gas Mixing
FLECHT SEASET Natural Circulation Tests			X	X	X		X		X			X	X	X	
CVTR Simulated DBA Tests				X	X	X	X	X			X				X
Marviken Full Scale Containment Tests	X	X		X	X		X	X		X		X			X
Battelle-Frankfurt Containment Tests	X			X	X	X	X	X							X
HEDL Hydrogen Mixing Tests	X			X	X	X	X	X							X
HDR Full Scale Containment Tests				X	X	X	X			X					X
NUPEC Tests	X			X			X	X							X
PRV Tests															
TOSQAN				X				X							
MISTRA				X				X							

Table 06.02.01-58-2—GOTHIC Model Validation Integral Test Matrix (Reference 4) (3 Sheets)

	Phenomenon/GOTHIC Model								
Integral Test	Vapor Compression	Vapor Decompression	Liquid Decompression	Jet Mixing	Mass Diffusion in Vapor	Turbulence	Buoyant Plume Behavior	Critical Flow	Pump Performance
FLECHT SEASET Natural Circulation Tests		X	X						X
CVTR Simulated DBA Tests	X	X		X	X	X			
Marviken Full Scale Containment Tests	X	X							
Battelle-Frankfurt Containment Tests	X	X			X	X	X		
HEDL Hydrogen Mixing Tests				X	X	X	X		
HDR Full Scale Containment Tests	X	X							
NUPEC Tests	X	X							
PRV Tests	X							X	
TOSQAN				X					
MISTRA				X					

Question 06.02.01-59:

The response to RAI 221 06.02.01-46 states that for hot leg breaks the ECCS configuration in Technical Report ANP-10299P, Section 8.1.4, will be modified to incorporate the impact of the transition to hot leg injection, which will result in a reduction of pumped ECCS to the cold legs. The ECCS configuration in the hot leg break scenario will consider that ECCS will be aligned to the hot legs at 3600 seconds and spill out the break; only the medium head safety injection (MHSI) and a portion of the low head safety injection (LHSI) will be delivered to the cold legs for core cooling. When will these modifications to ANP-10299P be done and presented to the staff? What are assumptions for the hot leg injection water after it spills from the break? Does it mix in the containment atmosphere or is it spilled on the containment floor? Is this done in RELAP5-BW or in GOTHIC portion of the mass and energy release analysis?

Response to Question 06.02.01-59:

The containment pressurization analysis for a double-ended guillotine hot leg break case has been completed and is discussed in U.S. EPR FSAR Tier 2, Section 6.2.1.4. The emergency core cooling system (ECCS) configuration in Technical Report ANP-10299P, Section 8.1.4 was revised as described in the response to RAI 221, Question 06.02.01-46. Technical Report ANP-10299P, Chapter 8 provides the general approach to performing the loss of coolant accident (LOCA) containment analyses and was not revised to include a specific discussion of hot leg breaks.

After the reactor coolant system (RCS) reaches a quasi-steady state condition, the only flow path for the cold leg injected ECCS water is:

Cold leg → downcomer → reactor core → out of the break.

Figure 06.02.01-59-1 shows the flow pattern in the reactor vessel before low head safety injection (LHSI) realignment. The mass and energy balance equations during this phase are:

$$M_{ECCS} \approx M_{Break}$$

$$M_{ECCS} h_{ECCS} + Q \approx M_{Break} h_{Break}$$

Where Q is the heat addition to the ECCS water, including the core decay heat and sensible energy from the metal. This phase can be modeled as a single boiling pot, and the mass and energy release can be calculated by either RELAP5 or GOTHIC code.

After hot leg injection, a portion of the LHSI is realigned for hot leg injection. The LHSI injected to the hot legs is assumed to bypass the core and flow back directly to in-containment refueling water storage tank (IRWST) without mixing in the containment atmosphere or spilling on the containment floor. This is done in the GOTHIC portion of the mass and energy release analysis. In the GOTHIC model, the LHSI injected in to the hot legs is lumped together with the LHSI recirculation flow and returned to IRWST. The available ECCS water for the core cooling during this phase is the medium head safety injection (MHSI) and the remaining LHSI delivered to the cold legs. Figure 06.02.01-59-2 shows the GOTHIC model after LHSI realignment.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Figure 06.02.01-59-1—Flow Patterns in the Reactor Vessel Before LHSI Realignment

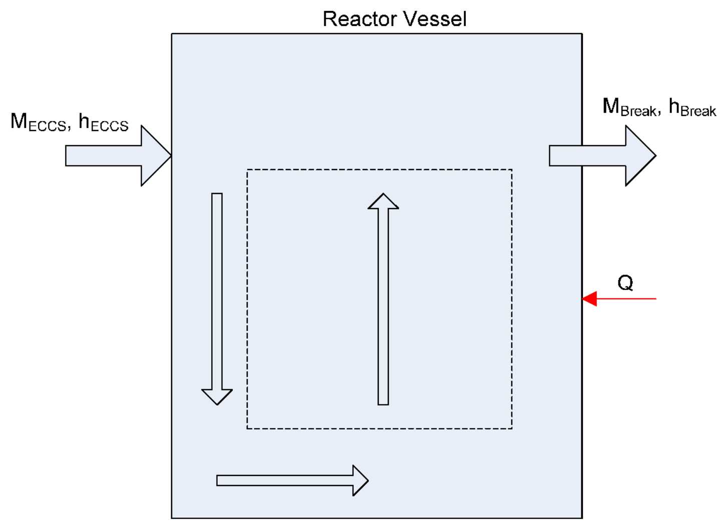
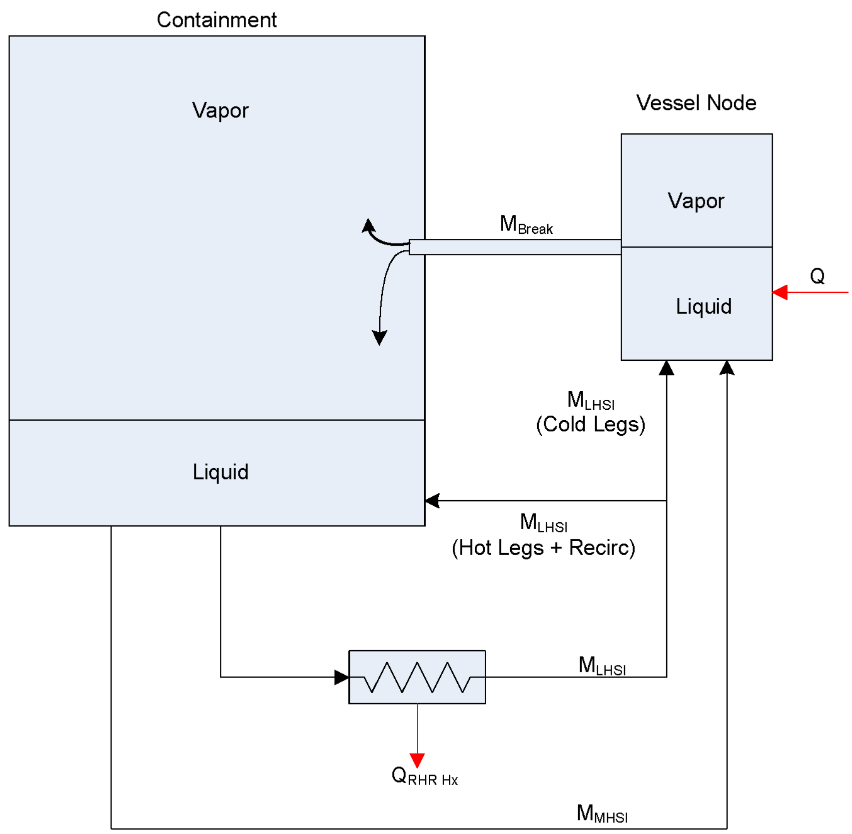


Figure 06.02.01-59-2—GOTHIC Long-Term Model after LHSI Realignment



Question 06.02.01-60:

The response to RAI 221 06.02.01-46 states that for hot leg breaks the transition time between RELAP5/MOD2-BW and GOTHIC will be made when the reactor coolant system (RCS) reaches a quasi-steady state condition which can be modeled in GOTHIC as a boiling pot but that the time will be before HLI at 3600 seconds. What criteria must be met to determine that a quasi-steady state condition occurs? What if these conditions are not met before 3600 seconds?

Response to Question 06.02.01-60:

The GOTHIC model presented in Technical Report ANP-10299P can be used to calculate the hot leg break mass and energy release as soon as the reactor coolant system (RCS) reaches a quasi-steady state condition. For the hot leg break, a quasi-steady state is defined to exist when the core has quenched and there is no significant flow across the steam generator (SG) tubes. Given the ECCS configuration, the requirement of a quasi-steadystate condition will always be met by 3600 seconds for a large break LOCA located in a hot leg. For a large hot leg break, this typically occurs in the first few hundred seconds after the break. For the double-ended guillotine case presented in the U.S. EPR FSAR, the water level reaches the reactor vessel (RV) nozzle elevation at approximately 1500 seconds, signifying a complete quench. Because the emergency core cooling system (ECCS) water must traverse the core to exit the break, the production of steam is terminated, and the steady-state condition has been satisfied. At this point, the mass and energy release can be calculated by GOTHIC. To simplify the calculation, the RELAP5 model is used to calculate the mass and energy release until the hot leg injection is activated. After hot leg injection, the long-term GOTHIC model is used to calculate the mass and energy release.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Question 06.02.01-64:

For the LOCA Mass and Energy release cases for which off site power was assumed to be present, describe the assumptions that were used for tripping the reactor coolant pumps during the course of the accident analysis.

Response to Question 06.02.01-64:

If offsite power is available, for a loss of coolant accident (LOCA) event, the four reactor coolant pumps (RCPs) are tripped on the "Low ΔP across RCP" signal for any RCP concurrent with a safety injection signal, as discussed in U.S. EPR FSAR Tier 2, Section 7.3.1.2.15. The combination with the safety injection signal avoids a spurious RCP trip. The ΔP refers to the pressure difference between the RCP inlet (crossover leg pressure) and the RCP outlet (cold leg pressure). The U.S. EPR provides a "Low ΔP across RCP" trip when the differential pressure across the pump falls to 80 percent of the pump's normal operating ΔP.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Question 06.02.01-65:

FSAR Section 6.2.1.3 states that the containment pressure for the containment M&E release matched the predicted GOTHIC containment pressure profile. Discuss how this was done for the portions the calculations for which containment pressure is input into RELAP5-BW.

Response to Question 06.02.01-65:

The containment backpressure input into the RELAP5-BW analyses in U.S. EPR FSAR Tier 2, Section 6.2.1.3 was determined through iteration with the GOTHIC code to verify a conservative mass and energy release rate. The time-dependent volume attached to the RELAP5-BW break node includes a representative containment pressure. The pressure was compared with the GOTHIC results and revised to converge on a containment pressure that is consistent with the mass and energy release rate for each break size and location. Figure 06.02.01-65-1 illustrates the comparison of the GOTHIC containment pressure with the RELAP5 inputs for the time dependent volume.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Figure 06.02.01-65-1—CLPD Containment Pressure Comparison