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Project 717

MFN 03-083
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U.S. Nuclear Regulatory Commission
Document Control Desk
Washington, D.C. 20852-2738

Attention: Chief, Information Management Branch
Program Management
Policy Development and Analysis Staff

Subject: **Retransmittal of Response to Request for Additional Information (RAI) numbers (6, 15, 35, 45, 47, 48, 60, 65, 67, 77, 89-92, 94, 95, 97, 105, 159, 264, 271, 298, 299, 304, 305, 307, 310 317, 321, 324, 326, 329, 331, 387, 388, 406, and 408) for ESBWR Pre-application Review.**

GE Nuclear Energy is re-submitting, in enclosures 1 and 2, responses to Requests for Additional Information (RAI) numbers, (6, 15, 35, 45, 47, 48, 60, 65, 67, 77, 89-92, 94, 95, 97, 105, 159, 264, 271, 298, 299, 304, 305, 307, 310 317, 321, 324, 326, 329, 331, 387, 388, 406, and 408) which were included in the referenced letters. This letter replaces our previous letter MFN 03-080 in its entirety. Please destroy all copies of MFN 03-080 and its attachments.

Enclosure 1 contains the responses with GE proprietary information as defined by 10CFR2.790. GE customarily maintains this information in confidence and withholds it from public disclosure. Enclosure 1 also includes RAI responses which contain no proprietary information in order to form a complete package. A non-proprietary version of the responses to the NRC's requests are provided in Enclosure 2.

The affidavit contained in Enclosure 3 identifies that the information contained in Enclosure 1 has been handled and classified as proprietary to GE. GE hereby requests that the information of Enclosure 1 be withheld from public disclosure in accordance with the provisions of 10 CFR 2.790 and 9.17.

If you have any questions about the information provided here, please let me know.

D068

Sincerely,

Atambir S. Rao

Reference:

1. MFN 03-049, Letter From Amy E. Cubbage (NRC) To Atam S. Rao (GE), May 16, 2003, SUBJECT: REQUEST FOR ADDITIONAL INFORMATION LETTER NO. 1 RELATED TO ESBWR PRE-APPLICATION REVIEW (TAC NO. MB6801)
2. MFN 03-050, Letter From Amy E. Cubbage (NRC) To Atam S. Rao (GE), May 20, 2003, SUBJECT: REQUEST FOR ADDITIONAL INFORMATION LETTER NO. 2 RELATED TO ESBWR PRE-APPLICATION REVIEW (TAC NOS. MB6279, MB6280, MB6281, AND MB7255)
3. MFN 03-052, Letter From Amy E. Cubbage (NRC) To Atam S. Rao (GE), June 20, 2003, SUBJECT: REQUEST FOR ADDITIONAL INFORMATION LETTER NO. 4 RELATED TO ESBWR PRE-APPLICATION REVIEW (TAC NOS. MB6283 AND MB6801)
4. MFN 03-053, Letter From Amy E. Cubbage (NRC) To Atam S. Rao (GE), July 17, 2003, SUBJECT: REQUEST FOR ADDITIONAL INFORMATION LETTER NO. 5 RELATED TO ESBWR PRE-APPLICATION REVIEW (TAC NOS. MB6279, MB6281, AND MB7255)
5. MFN 03-054, Letter From Amy E. Cubbage (NRC) To Atam S. Rao (GE), July 17, 2003, SUBJECT: REQUEST FOR ADDITIONAL INFORMATION LETTER NO. 6 RELATED TO ESBWR PRE-APPLICATION REVIEW (TAC NO. MB6801)
6. MFN 03-065, Letter From Amy E. Cubbage (NRC) To Atam S. Rao (GE), July 17, 2003, SUBJECT: REQUEST FOR ADDITIONAL INFORMATION LETTER NO. 7 RELATED TO ESBWR PRE-APPLICATION REVIEW (TAC NO. MB6801)
7. MFN 03-066, Letter From Amy E. Cubbage (NRC) To Atam S. Rao (GE), July 17, 2003, SUBJECT: REQUEST FOR ADDITIONAL INFORMATION LETTER NO. 8 RELATED TO ESBWR PRE-APPLICATION REVIEW (TAC NOS. MB6280 AND MB6281)
8. MFN 03-069, Letter From Amy E. Cubbage (NRC) To Atam S. Rao (GE), August 8, 2003, SUBJECT: REQUEST FOR ADDITIONAL INFORMATION LETTER NO. 9 RELATED TO ESBWR PRE-APPLICATION REVIEW (TAC NOS. MB6280 AND MB6801)

Enclosures:

1. MFN 03-083 Responses to RAI numbers (6, 15, 35, 45, 47, 48, 60, 65, 67, 77, 89-92, 94, 95, 97, 105, 159, 264, 271, 298, 299, 304, 305, 307, 310 317, 321, 324, 326, 329, 331, 387, 388, 406, and 408) - Proprietary Information
2. MFN 03-079 Responses to RAI numbers (6, 15, 35, 45, 47, 48, 60, 65, 67, 77, 89-92, 94, 95, 97, 105, 159, 264, 271, 298, 299, 304, 305, 307, 310 317, 321, 324, 326, 329, 331, 387, 388, 406, and 408) - Non-proprietary Information – to be provided separately
3. Affidavit, David J. Robare, dated September 5, 2003

cc:	A. Cubbage	USNRC (with enclosure)
	J. Lyons	USNRC (w/o enclosure)
	G.B. Stramback	GE (with enclosure)

General Electric Company

AFFIDAVIT

I, David J. Robare, state as follows:

(1) I am Technical Projects Manager, Technical Services, General Electric Company ("GE") and have been delegated the function of reviewing the information described in paragraph (2) which is sought to be withheld, and have been authorized to apply for its withholding.

(2) The information sought to be withheld is contained in the Enclosure 1 of GE letter MFN 03-083, Atambir S. Rao to NRC, *Response to Request for Additional Information (RAI) numbers (*6, 15, 35, 45, 47, 48, 60, 65, 67, 77, 89-92, 94, 95, 97, 105, 159, 264, 271, 298, 299, 304, 305, 307, 310 317, 321, 324, 326, 329, 331, 387, 388, 406, and 408*) for ESBWR Pre-application Review,* dated September 5, 2003. The proprietary information is in Enclosure 1, *Response to NRC RAI numbers (*6, 15, 35, 45, 47, 48, 60, 65, 67, 77, 89-92, 94, 95, 97, 105, 159, 264, 271, 298, 299, 304, 305, 307, 310 317, 321, 324, 326, 329, 331, 387, 388, 406, and 408*)*. For text and text contained in tables, GE proprietary information is identified by a double underline inside double square brackets. Figures and large equation objects are identified with double square brackets before and after the object. In each case, the superscript notation{3} refers to Paragraph (3) of this affidavit, which provides the basis for the proprietary determination.

(3) In making this application for withholding of proprietary information of which it is the owner, GE relies upon the exemption from disclosure set forth in the Freedom of Information Act ("FOIA"), 5 USC Sec. 552(b)(4), and the Trade Secrets Act, 18 USC Sec. 1905, and NRC regulations 10 CFR 9.17(a)(4), and 2.790(a)(4) for "trade secrets" (Exemption 4). The material for which exemption from disclosure is here sought also qualify under the narrower definition of "trade secret", within the meanings assigned to those terms for purposes of FOIA Exemption 4 in, respectively, Critical Mass Energy Project v. Nuclear Regulatory Commission, 975F2d871 (DC Cir. 1992), and Public Citizen Health Research Group v. FDA, 704F2d1280 (DC Cir. 1983).

(4) Some examples of categories of information which fit into the definition of proprietary information are:

a. Information that discloses a process, method, or apparatus, including supporting data and analyses, where prevention of its use by General Electric's competitors without license from General Electric constitutes a competitive economic advantage over other companies;

b. Information which, if used by a competitor, would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product;

c. Information which reveals aspects of past, present, or future General Electric customer-funded development plans and programs, resulting in potential products to General Electric;

d. Information which discloses patentable subject matter for which it may be desirable to obtain patent protection.

The information sought to be withheld is considered to be proprietary for the reasons set forth in paragraphs (4)a., and (4)b, above.

(5) To address 10 CFR 2.790 (b) (4), the information sought to be withheld is being submitted to NRC in confidence. The information is of a sort customarily held in confidence by GE, and is in fact so held. The information sought to be withheld has, to the best of my knowledge and belief, consistently been held in confidence by GE, no public disclosure has been made, and it is not available in public sources. All disclosures to third parties including any required transmittals to NRC, have been made, or must be made, pursuant to regulatory provisions or proprietary agreements which provide for maintenance of the information in confidence. Its initial designation as proprietary information, and the subsequent steps taken to prevent its unauthorized disclosure, are as set forth in paragraphs (6) and (7) following.

(6) Initial approval of proprietary treatment of a document is made by the manager of the originating component, the person most likely to be acquainted with the value and sensitivity of the information in relation to industry knowledge. Access to such documents within GE is limited on a "need to know" basis.

(7) The procedure for approval of external release of such a document typically requires review by the staff manager, project manager, principal scientist or other equivalent authority, by the manager of the cognizant marketing function (or his delegate), and by the Legal Operation, for technical content, competitive effect, and determination of the accuracy of the proprietary designation. Disclosures outside GE are limited to regulatory bodies, customers, and potential customers, and their agents, suppliers, and licensees, and others with a legitimate need for the information, and then only in accordance with appropriate regulatory provisions or proprietary agreements.

(8) The information identified in paragraph (2), above, is classified as proprietary because it details for licensing application of TRACG to the ESBWR passive safety system design of the BWR. This TRACG code has been developed by GE for over fifteen years, at a total cost in excess of three million dollars. The reporting, evaluation and interpretations of the results, as they relate to the ESBWR, was achieved at a significant cost, to GE.

The development of the evaluation process along with the interpretation and application of the analytical results is derived from the extensive experience database that constitutes a major GE asset.

(9) Public disclosure of the information sought to be withheld is likely to cause substantial harm to GE's competitive position and foreclose or reduce the availability of profit-making opportunities. The information is part of GE's comprehensive BWR safety and technology base, and its commercial value extends beyond the original development cost. The value of the technology base goes beyond the extensive physical database and analytical methodology and includes development of the expertise to determine and apply the appropriate evaluation process. In addition, the technology base includes the value derived from providing analyses done with NRC-approved methods.

The research, development, engineering, analytical and NRC review costs comprise a substantial investment of time and money by GE.

The precise value of the expertise to devise an evaluation process and apply the correct analytical methodology is difficult to quantify, but it clearly is substantial.

GE's competitive advantage will be lost if its competitors are able to use the results of the GE experience to normalize or verify their own process or if they are able to claim an equivalent understanding by demonstrating that they can arrive at the same or similar conclusions.

The value of this information to GE would be lost if the information were disclosed to the public. Making such information available to competitors without their having been required to undertake a similar expenditure of resources would unfairly provide competitors with a windfall, and deprive GE of the opportunity to exercise its competitive advantage to seek an adequate return on its large investment in developing these very valuable analytical tools.

I declare under penalty of perjury that the foregoing affidavit and the matters stated therein are true and correct to the best of my knowledge, information, and belief.

Executed on this 5TH day of SEPTEMBER 2003.

David J. Robare
General Electric Company

ENCLOSURE 2

MFN 03-083

Response to NRC RAI numbers (6, 15, 35, 45, 47, 48, 60, 65, 67, 77, 89-92, 94, 95, 97, 105, 159, 264, 271, 298, 299, 304, 305, 307, 310, 317, 321, 324, 326, 329, 331, 387, 388, 406, and 408)

Q6. Is there a matrix of TRACG calculations (Design Record Files) to support TRACG validation, assessment for ESBWR application and ECCS/Transient analyses? If not, please provide a table which lists all the TRACG calculations within the scope of ESBWR pre-application.

R6. Tables 6-1 and 6-2 summarize the ESBWR TRACG ECCS/LOCA and Containment/LOCA cases within the scope of the ESBWR Application Report (NEDC-33083P).

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Q15. Absence of a quantitative bottom-up scaling analysis :
In page 10-2 of the ESBWR Scaling report (NEDC-33082P), the last sentence of 4th paragraph states that, "Much of the bottom-up results are borrowed from the SBWR scaling report rather than repeating them in this report." The staff, however, notes that in letter dated May 14, 1996, from NRC to GE, "Staff Review of GE Scaling Report NEDC-32288P, Rev. 1, Scaling of SBWR Related Tests, Related to Reactor Systems Area," it was stated in Items 3 and 4 that, "....while the H2TM approach uses both top-down scaling for systems or components, and bottom-up scaling that focuses on phenomenology, GE's approach provides a quantitative evaluation only on the basis of top-down scaling parameters. The bottom-up approach is discussed in a qualitative fashion in the scaling report, but a quantitative analysis is not presented. The lack of a bottom-up scaling analysis means that there is no explicit link between significant SBWR phenomena, as identified in GE's Phenomena Identification and Ranking Tables (PIRTs) for the SBWR, and the test facility scaling. This failure to link the PIRT and scaling is the major shortcoming of GE's report." In light of the fact that a quantitative bottom-up scaling analysis was not presented in the ESBWR Scaling report, the staff requests GE to submit such an analysis as part of the H2TM approach, clearly demonstrating explicit link between significant ESBWR phenomena, as identified in the PIRT and the test facility scaling.

R15. There are two major portions to the hierarchical two-tiered scaling (H2TS) approach: the first is top-down scaling, which is used to identify processes important to the system behavior; and the second is the bottom-up scaling, used to assess the adequate scaling of processes that are determined to be important from the top-down scaling. Therefore the quantitative top-down scaling presented in the ESBWR Scaling Report and supporting documents can be used to quantitatively confirm or adjust the ranking of PIRT phenomena identified in the TAPD (NEDC-33079P). GE agrees that the linkage between the top-down scaling parameters and PIRT phenomena is not clearly presented and has provided this linkage below, in order to quantify the PIRT rankings.

The set of important phenomena in the ESBWR is very limited, as demonstrated in the attached tables. The table at the end of this RAI response provides the bottom-up parameters associated with these important parameters and comments on their scaling.

15.1 Relationship Between PIRT Phenomena and Scaling Groups

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15.4 Summary

The tables provided in this RAI response provide the requested link between the PIRT parameters and scaling analysis. The PIRT ranking confirmation comes from the top-down scaling rather than the bottom-up scaling. Confirmation of the PIRT rankings are provided in the tables. In addition a summary of the bottom-up phenomena associated with the important PIRT phenomena is provided.

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Q35. Section 3.3 - When values of solution from the balance equations are restricted by critical flow or counter current flow limit (CCFL), is the time step repeated with smaller time, or are flows adjusted and calculation proceeds?

R35. The velocity is set to the [[
]] The critical flow model is described in Section 6.3 and the CCFL is described in Section 6.1.7.2. [[

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Q45. Equations 6.1-6 and 6.1-7 - Why are steady inertia terms neglected?

R45. The interfacial shear model is based on the two assumptions stated in Section 6.1.1 in the TRACG Model Description:

- For adiabatic and steady-state conditions, the two-fluid model and the drift flux model are equivalent, and drift flux parameters can be used to characterize the relative velocity, and the phase and flow distributions.
- The correlations for the interfacial shear and drag, as well as wall friction, as derived from adiabatic steady-state conditions, are applicable for transient conditions.

For adiabatic and steady state conditions in a straight fluid channel without any area changes there is no acceleration of the fluid and the $\frac{\partial}{\partial t}$ as well as the $\frac{\partial}{\partial x}$ terms are zero.

Q47. Equation 6.1-21- What type of averaging is implied on both sides of the equation?

R47. [[ ]] is defined by [[ ]], where the average indicated by <> is the cross-sectional average.

Q48. Critical Weber number is for the upper limit on the droplet size distribution. Is the GE recommended value conservative for LOCA application?

R48. The critical Weber number defines the maximum stable droplet size, [[ ]] was chosen as a representative size for the average droplet size. The excellent comparison to void fraction data shown in NEDE-32177P demonstrates the applicability of the model. Comparisons to integral effects LOCA tests such as TLTA and FIST as shown in NEDE-32177P also demonstrates the adequacy of the model. It should furthermore be kept in mind, that TRACG is not intended to be conservative but best estimate. Conservative estimates for the critical safety parameters are obtained as described in the application methodology LTR.

Q60. Section 6.6.6 - Four critical heat flux criteria are described. What options are used and where in ESBWR? What correlation is used for flow reversal or very low flows in the channel (Modified Zuber is excluded from the channel components)?

R60. [[

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Q65. Section 6.6.11 - What condensation model is used in containment? How much is the uncertainty in the correlation? How does condensation affect the early pressure peak during steam line break LOCA?

R65. For condensation in the containment, the option that is selected uses the minimum condensation heat transfer coefficient from the Uchida correlation and the Kuhn-Shrock Peterson (K-S-P) correlation with the shear enhancement facto) set to 1. The applicability to containment is discussed near the end of Section 6.6.11.1. For condensation in tubes, the K-S-P has a standard deviation of 7.4% compared to pure steam data and a standard deviation of 17.6% when compared to Kuhn's 70 steam-air tests as indicated in the first part of Section 6.6.11.3. The application for steam condensation in the containment is discussed later in Section 6.6.11.3. The various correlations are compared with each other in Figure 6.6-15 and they are compared to the data from Dehbi in Figure 6.6-16. For containment applications, ***TRACG Application for ESBWR, NEDC-33083P*** suggests using [[

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In general, the long-term heat transfer is dominated by conduction through the wall. As a result, any error in the condensation rate that in turn affects the heat transfer coefficient has essentially no impact on the total amount of condensed steam and the long-term containment response. The question rightly implies a concern with the short-term pressure response where the condensation rate could have some impact on the peak pressure. To address this concern, sensitivity studies have been performed to assess how potential variations in steam condensation in the containment impact the calculated peak containment pressure for a simulated steam line break LOCA. The sensitivity results are summarized in Table 65-1. The results for cases 1, 2 and 3 are not distinguishable within the numerical noise. This indicates two things: (1) The K-S-P correlation with $f_{1shear}=1$ is providing a lower condensation rate than the Uchida correlation and (2) the calculated value for $f_{1shear}\approx 1$. Case 4 shows that the impact of the condensation rate on the peak pressure must be relatively small because even a 25% increase in the heat transfer area for the drywell walls only causes a slight decrease in the peak pressure.

Table 65-1 Drywell Peak Pressure Sensitivity for Steam Line Break LOCA

Case #	Description	Peak Pressure (psia)
1	Reference (recommended for containment): Minimum of K-S-P with $f_{1shear}=1$ and Uchida	39.717
2	K-S-P with $f_{1shear}=1$	39.727
3	K-S-P with calculated f_{1shear}	39.727
4	Reference with 25% increase in heat transfer area	39.419

Q67. Figures 7.7-6 and 7.7-7 show upper and lower bands for carry under. There are expressions for upper limit for carryunder. Are there similar expressions for lower limit?

R67. The upper and lower bands shown in Figures 7.7-6 and 7.7-7 are the upper and lower boundaries for the experimentally observed carry under.

Q77. Section 7.5.2.6.1 (p. 7.5-17) - How are the inputs F_r and F_{kx} determined?

R77. [[

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The fuel gap conductance models in Sections 7.5.2 and 7.5.3 are identical to the SAFER/GESTR models approved by the NRC, and also reviewed in the TRACG application for AOOs.

Q89. Section 3.1.1.1 (p. 3-4) - The 8x8 rod bundle simulated a top-peaked power distribution. Was the power to the rods uniform? Are the heat fluxes noted in Table 3.1-2 axially averaged values for all 64 rods?

R89. The axial power distribution was top peaked. The radial rod to rod power distribution was [[ ]] The axial peaking was approximately 1.55 and the local rod to rod peaking was [[ ]] The heat flux in Table 3.1-2 is the [[ ]] for all the rods.

Q90. Section 3.1.1.2 (p. 3-6) - What is the uncertainty in using a single channel TRACG model to simulate a rod bundle test? Was the sub-channel effect negligible in the FRIGG test?

R90. TRACG uses a one-dimensional model for the fuel channel and calculates channel average properties. The void fraction measurement from the FRIGG utilized eight individual X-ray beams and produced the average void fraction for the channel. [[

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Q91. Section 3.1.1.5 (p. 3-10) - The sensitivity study investigated the effect of axial nodalization. How are sub-channel effects and the sensitivity to multiple parallel channels addressed?

R91. TRACG utilizes a one-dimensional model for the fuel channel. Cross-sectional variation is characterized through the distribution parameter Co in the interfacial shear model, see Section 6.1 in NEDE-32176P. The GEXL correlation for critical power empirically [[
]] See also the response to Question 90.

Qualification for parallel channels has been addressed in the SSTF qualification in the TRACG Qualification LTR (NEDE-32177P) Sections 4.3 and 5.3, and has also been addressed in the nodalization studies on channel grouping in the TRACG Qualification LTR (NEDE-32177P) Section 6.9.

Q92. Section 3.1.3 (p. 3-14 to 3-17) - In the Bartolomei tests void fraction was measured at different elevations. How is the void fraction shown in Figure 3.1-13 derived from the test data? A hot water coil provided heating to the test section and there should be an axial variation in the vapor volumetric flux in the heated section. Are the void fraction data shown in Figure 3.1-13 taken in the unheated section above the hot water coil?

R92. The void fraction measurements in the Bartolomei test were obtained from gamma ray attenuation data obtained in the adiabatic region above the heater coils. The test facility and the data are described in: G. G. Bartolomei, V. A. Suvorov and S. A. Tevlin, "Hydrodynamics of Steam Generation a Two–Circuit Nuclear Power Plant," Teploenergetika 10(1), p 52-57, 1963.

Q94. Section 3.1.5.3 (p. 3-26) - In Figure 3.1-22, the maximum level deviation is not within the measurement uncertainty as the report stated. Please explain.

R94. The report states that the level is within the measurement uncertainty over most of the test, but that the deviation increases to [[ ]] at the end of the test. This statement is for test 5803-01, where the level comparison is shown in Figure 3.1-24. For this test the measurement uncertainty is [[ ]].
Figure 3.1-22 is test 5801-15, and for this test it is stated at the top of page 3-26 that the maximum deviation is [[ ]]. For this test the measurement uncertainty is [[ ]].
The 5803 test series are liquid blow down tests. In these tests there is very little flashing before the uncovery of the break location. Therefore the water level is very well defined and the measurement accuracy is given by the accuracy of the pressure drop measurement. The 5801 test series are steam blow down tests. In these tests, the pressure decreases rapidly immediately after the break and there is a large amount of flashing below the level. Therefore the uncertainty in determining the two-phase level is significantly larger.

Q95. Section 3.1.5.3 (p. 3-27) - In Figure 3.1-23, would the use of measured break flow (Fig. 3.4-12) as a boundary condition result in better agreement with pressure data?

R95. The simulations were made to test both the critical flow and the void fraction models together. No attempt was made to use the measured break flow.

Q97. Section 3.2.2.4 (p. 3-40) - In Figure 3.2-9, how does the rod number correspond to the position of the rods in the 8x8 bundle?

R97. The rod numbers from 1 to 64 for the 8X8 bundle are shown in Figure 97-1. Rod number [[ ]] In Figure 3.2-9, the numbers [[ ]] There is an error in Figure 3.2-9. The legends between data and TRACG have been reversed and thus TRACG underpredicts the peak temperature by [[ ]] rather than overpredicting the temperature by [[ ]]. In either case, [[ ]] is a very small error on a peak cladding temperature of approximately [[ ]] The rod temperature is conservatively overpredicted for the peripheral rods (1 and 64) because the local vapor temperature in the vicinity of the cold channel box is less than the bulk vapor temperature. In Figure 3.2-7, the rod group for rod 28 in Figure 97-1 should have been rod group 10. These typographical errors will be corrected in the next revision of the report.

1	2	3	4	5	6	7	8
9	10	11	12	13	14	15	16
17	18	19	20	21	22	23	24
25	26	27	28	29	30	31	32
33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48
49	50	51	52	53	54	55	56
57	58	59	60	61	62	63	64

Figure 97-1. Rod Numbers for the CSHT Test Facility

Q105. Section 3.5.1 (p. 3-65) - How do the thermal-hydraulic characteristics of the ATLAS test bundle simulating GE9 fuel compare with the ESBWR fuel assembly?

R105. The fuel bundles used for the demonstration analysis in the ESBWR application methodology are of the GE12 design. The actual fuel design to be loaded into the ESBWR will likely be different based on the timing, but will use the latest licensed GNF fuel.

The GE12 design utilizes a 10 x 10 fuel rod array, which includes 78 full-length fuel rods, 14 part length fuel rods and 2 large central water rods. The active fuel length is approximately 3.05 m (10 ft) compared to the active fuel length of approximately 3.66 m (12 ft) for operating BWRs. A comparison of the principal dimensions between GE9 and the ESBWR GE12 bundle are shown in the table below.

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Lattice	GE9	ESBWR GE12
Number of heated rods	60	92
Number of unheated rods	1	2
Diameter of heated rods	12.27 mm	10.26 mm
Diameter of unheated rods	34.0 mm	24.9 mm
Channel width (inside)	134.1 mm	134.1 mm
Heated length	3.81 m	3.05 m
Number of part length rods (PLR)	0	14
Length of part length rods	N/A	2.19 m
Hydraulic diameter in fully rodded section	13.5 mm	10.2 mm
Hydraulic diameter above PLRs	N/A	13.1mm
Number of spacers	7	6
Type of spacer	Ferrule	GE12

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While the data for the two lattices are compared as requested, it is important to mention that GE/GNF perform full scale tests of all fuel designs prior to use. Thus, a more relevant comparison would be between full-length and shorter GE12 designs for which all parameters are matched except for active fuel length. Pressure drop data and GEXL correlation coefficients are available for full-length GE12 designs. Transient tests have also been performed to validate the application of the GEXL correlation for GE12 fuel.

The pressure drop correlations (friction, spacers, tieplates, etc) are applicable to the shorter length fuel. [[

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Q159. NEDC-33083P states "A complete description of the ESBWR containment model can be found in Section 8.2 of Reference 24." Reference 24 is NEDC-32725P, "TRACG Qualification for SBWR," Rev. 1, Volumes 1 and 2, September 1997. In comparing Figure 3-7-1 in NEDC-33083P and Figure 8.2-5 in NEDC-32725P, any description in NEDC-32725P would not be fully representative of the ESBWR, because of the differences in ESBWR as compared to the SBWR design. Please provide supplemental information to address this issue.

R159. The key differences between the ESBWR and SBWR containment model are provided in the following.

(a) ESBWR model radial boundaries

Radial boundary	Location	Value (m)
1	Radius of RPV shroud (mid-wall)	[[ ]]
2	RPV inside radius	[[ ]]
3	Intermediate location in DW	[[ ]]
4	Annulus DW outer radius	[[ ]]
5	Intermediate location in WW	[[ ]]
6	Inner radius of containment wall	[[ ]]

(b) PCC Drain Tanks
The ESBWR PCC drain line PIPE84 connects to drain tank TEE62. Top of TEE62 connects to the DW and bottom of TEE62 connects to VLVE44 which returns PCC drain to the RPV. Components TEE62 and VLVE44 are additional components not simulated in the SBWR model.

The ESBWR PCC drain line PIPE46 connects to drain tank TEE63. Top of TEE63 connects to the DW and bottom of TEE63 connects to VLVE45 which returns PCC drain to the RPV. Components TEE63 and VLVE45 are additional components not simulated in the SBWR model.

(c) GDCS pool and airspace
The ESBWR GDCS pools and airspace have no direct connection to the DW.

(d) GDCS airspace and WW connections
PIPE81 and PIPE82 are used to model the connections between the ESBWR GDCS airspace and WW airspace.

(e) SRV modeling
There are a total of 12 SRVs, 3 SRVs for each ESBWR main steam line. VLVE24 models 3 SRVs and VLVE28 models 6 SRVs, from the intact MSLs. The 3 SRVs from the broken MSL were not modeled in the MSL break case.

(f) DPV modeling

There are a total of 8 DPVs, one DPV for each of the MSLs, and 4 DPVs connect to the RPV via the DPV/IC nozzles. VLVE19 models 3 DPVs from the intact MSLs. VLVE12 and VLVE13 represent 2 DPVs each. The DPV from the broken MSL was not modeled in the MSL break case.

Q264. The scaling of vertical piping follows the traditional scaling approach. Particular care should be taken in locating the concentrated losses because the liquid level may or may not be present at these specific elevations of the piping during portion of the transient. Could you elaborate on the representation of the distributed losses with concentrated losses in view of this possibility.

R264. The conditions in most of the lines in the plant and facility fall into one of two situations: either there is through flow in the line and the flow is single phase; or, there is little or no flow in the line and the flow is controlled by a balance between driving pressure difference and submergence so that the friction/distributed losses are not important (such as the main and PCC vents). In the first case the location of the distributed loss does not matter since the flow is single phase. In the latter case, the pressure drop associated with friction and distributed losses are negligible. The only time that there is a mixture of gas or vapor and liquid in these lines is when there is no flow or during the short startup transient when liquid is being cleared out of the lines. As was discussed in the SBWR scaling report, flow startup transients are not important to the behavior of the system. The flows in the lines of the ESBWR are controlled by a balance between the driving pressure resulting from the difference in pressure between the two volumes connected by the line and either the friction and distributed losses in the pipe or the submergence losses.

Each of the lines and the importance of the distributed losses in them are discussed in the table below. This is done by temporal phase since the importance of the distributed losses and conditions in the different lines can vary from phase to phase.

Line	Remarks
Long-term phase	
GDCS line	There is no flow in this line in the long-term period
PCCS return line	This line returns condensed liquid from PCC. The rate is determined by PCC condensation rate. The flow rate results from a balance between hydrostatic head and friction losses in the pipe. The elevation difference between the level in the pipe and the RPV will adjust until all of the condensed steam is returned to the vessel. Therefore differences in friction losses will just result in an adjustment in the water level in the pipe. The overall effect on the system is negligible.
RPV to DW (DPVs and/or broken main steam line)	The flow in this path is always gas or steam in the long-term so the location of distributed losses is not important
PCC inlet	The flow in this path is always gas or steam in the long-term so the location of distributed losses is not important.
PCC vent	The small flow rates in the vent lines are controlled by a balance between pressure difference and submergence. Therefore the friction and distributed losses are unimportant.
Main vent	The small flow rates in the vent lines are controlled by a balance between pressure difference and submergence. Therefore the friction and distributed losses are unimportant.
Mid-term phase	
GDCS line	Friction and distributed losses are important since they control the rate of GDCS flow. The pipe is filled with liquid so the location of the losses is not important.
Other lines	Conditions are similar to long-tern phase
Blowdown phase	
DPV and MSL	The flow in this path is always gas or steam so the location of distributed losses is not important
SRV	The tests do not cover the startup transient when the vents are cleared at the beginning of blowdown. Subsequent to this the flow is either single phase or there is no flow.
PCC vent/Main vent	The tests do not cover the startup transient when the vents are cleared at the beginning of blowdown. Subsequent to this the flow is either single phase or there is no flow.

Q271. The second sentence on page 4-11 says "The volume fill time t_r is the natural scale for subsystems and processes where volume emptying or filling due to mass flows take place." The fill time is not a "natural" characteristic of any vessel because it depends on the magnitude of the input flow. Since the input flow drives the response of the vessel, the vessel is no longer an independent dynamic component and has no characteristic time of its own to contribute. Please clarify your statement in light of the volume fill time not being a truly natural time scale.

R271. The filling time may not be a "natural" characteristic of the vessel or a time constant of the vessel, however, it is the reference time that will render the non-dimensional time, t^+, of order 1 for the rate of change of RPV liquid mass equation. It is therefore the reference time used for the GDCS (Reflood) phase in the RPV (see Section 7.3.2 of the report). In future revisions of the report, the text will be revised to eliminate calling this "reference time" a "natural time" or a "time constant".

Q298. On page 3-20 of NEDC-33083P, "TRACG Application for ESBWR," General Electric (GE) states that because of the limited ability of TRACG to model condensation on horizontal surfaces, part of the diaphragm floor is included in the vent wall heat slab. Mass and heat transfer from horizontal structures differs from mass and heat transfer on vertical structures. Lumping the structures may also effect the definition of the characteristic length used to determine whether the mass and heat transfer process is laminar or turbulent. Describe how the combined heat structure was created, including a discussion of the physical properties (materials, thickness, etc.) and the Biot number (the measure of the thermal internal resistance to the surface film resistance) for each structure and the combined structure to support this model. Provide justification that this model is conservative for this purpose.

R298. Most of the heat slabs in the ESBWR containment wall (volume boundaries) are vertical surfaces. Non-wall heat structures inside the DW and WW are conservatively ignored. The horizontal heat slabs are the drywell and suppression pool basemats, the diaphragm floor and the drywell top slab. The two basemats are covered with water and will not see any direct condensation. These two basemats were conservatively not modeled in the calculations. The diaphragm floor in the wetwell airspace also is not expected to see any condensation and was conservatively not modeled. The remaining two horizontal surfaces in the drywell are the diaphragm floor (not part of the GDCS pools) and the drywell top slab. The top slab was conservatively not modeled. The diaphragm floor, which is not part of the GDCS pools transfers energy from the DW to the WW airspace during the transient. To model this heat conduction, the diaphragm floor was modeled and accounted for as part of the vertical wall between the DW and WW. The vertical wall between the DW and WW (Levels 6 and 7 in Figure 3.7-1) includes the diagram floor area and assumes wall thickness same as that for the diaphragm floor [[ ]] This simplification in the modeling is expected to have a very small impact on the containment response, as the heat slabs have a very small impact on both the short-term and long-term DW pressure. A sensitivity study was performed to study the impact of this vertical heat slab modeling. In this study, the areas of the vertical heat slab between the DW and WW were [[ ]] The impact on the calculated long-term containment pressure was a change of [[ ]]

Q299. On page 3-21 of NEDC-33083P, GE states that certain regions with dead end connections were eliminated but their volumes were maintained in the overall model. This was done to address difficulties in TRACG to control the release of noncondensible gases from these regions. Describe these regions (general location, size, volume, flow path areas, etc.). Are the heat structures associated with these regions included in the model? The calculations are based on a uniform relative humidity in the drywell, with a lower bound value to maximize the noncondensible gases present at the start of the analysis. Are these regions large enough and isolated (by flow restrictions) such that the relative humidity in these regions could be less than the average resulting in a large inventory of noncondensible gases which could be transported to the wetwell?

R299. Unlike the SBWR design, where the spaces above the GDCS pools were easily identified volumes where the noncondensable gases could accumulate, there are no such large significant volumes with dead end connections in the ESBWR drywell. All other volumes in the drywell are reasonably well connected that the relative humidity and other conditions in any volumes are expected to be uniform. As discussed in RAI 164, the TRACG model does not handle [[ ]] To handle the possible hideout of non-condensable gases in the lower drywell, a simplified volume [[ ]] is used in the ESBWR nodalization.

Q304. In the PANDA tests (Section 5.7 of NEDC-32725P) it was noted that there was little or no axial stratification in the drywell. However, the TRACG models maintains stratification over the long-term, out to 48 hours (Fig. 3.7-3, NEDC-33083P).

Q304.1. Explain the mass and heat transport processes in TRACG which sustain this axial stratification. Are there integral or separate effects test which show this sustained axial stratification? How would complete mixing effect the calculated performance on the passive containment cooling system (PCCS) and the containment response to the main steam line break (MSLB) (maintaining a high level of noncondensible gases near the PCCS inlet)?

R304.1 The PANDA tests have an open drywell geometry, which promotes good mixing. TRACG also calculated good mixing for the PANDA tests and the noncondensibles were quickly swept out of the drywell region into which the steam was injected. In tests where there was a stagnant drywell (i.e. in which the steam was injected in only one of the drywell volumes and the PCCs in the other drywell were not in service), TRACG undercalculated the mixing in the stagnant drywell. In particular, the noncondensibles in the region below the connecting pipe in the stagnant drywell remained in that region in the TRACG calculations, whereas some were swept out in the tests. PANDA did not simulate the restricted lower drywell region, which would not have mixed with the upper drywell.
TRACG transports noncondensibles with the same velocity as the steam; i.e., only one gas phase velocity is calculated. In regions where there are high steam velocities due to the injection of break flow, noncondensibles are quickly swept out with the steam. In regions at the bottom of the vessel, that are not in the primary flow field between the break discharge and exit vents or PCCs, the velocities are low and noncondensible flow may be undercalculated. The circulation velocities are calculated based on the wall friction in the cells in the drywell annulus. Turbulent mixing between cells is not calculated.

The limitations of TRACG with respect to mixing and transport of noncondensibles have been recognized, and the effects analyzed through parametric studies. The issue of complete versus incomplete mixing was dealt with in the studies reported in Table 3.3-5 of NEDC-33083P. The location of the steam line break was artificially varied from axial level 1 through 10 (See Figure 3.7-1 of NEDC-33083P). This was an artifice to vary the mixing of the noncondensibles in the upper drywell. When the break flow was injected in Level 1, the entire upper drywell is well mixed. For break discharge into the higher levels, only the regions above the break location are well mixed. Table 3.3-5 shows a decrease

in the peak pressure from [[ ]] as a result of the drywell being completely mixed. Note that most of the decrease is a result of good mixing in the region above the annulus (Level 8 through 10).

The pressure increase in the containment is a consequence of moving the noncondensibles over from the drywell to the wetwell gas space together with an increase in the vapor pressure due to heating of the suppression pool. Beyond 50 hours, all the noncondensibles from the upper drywell have been moved to the wetwell for all cases shown in Table 3.3-5. The energy to the suppression pool due to PCCS heat transfer degradation is minimized for the well mixed case, for which there is a high concentration of noncondensible at the inlet to the PCCS, but for a shorter period of time.

Q304.2. Provide a figure similar to Fig. 3.7-3 for the bounding case analysis.

R304.2. Figure 304-1 shows the Drywell noncondensible partial pressure for the bounding case analysis.

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Q305. Figure 6.6-16 in the TRACG Model Description reports uses the units "WALLS/m^2K" for the average heat transfer coefficient. Should these units be "watts/m^2-K?"

R305. Yes, the units should be watts/m^2-K. The typographical error will be corrected in the next revision of the Model Description report.

Q307. In NEDE-32176P, Rev 1, it is stated that "If the containment contains significant amounts of horizontal surface area, care should be taken to model this area with a non-horizontal equivalent area since no condensation heat transfer will be predicted using g*cos(0°) = 0.0."

Q307.1. For the ESBWR, is this a concern? If so, how are horizontal surfaces treated in the calculations? Provide a description of the heat structures (wall, piping, etc.) considered in the calculations in the drywell, the suppression pool and the wetwell and the mass and heat transfer correlations being used for condensation, convection and, if appropriate, radiation (based on the expected flow regime - laminar or turbulent, and orientation - vertical or horizontal). Identify the horizontal surfaces that are being treated as non-horizontal.

R307.1. See the response to RAI298 for the discussion of ESBWR containment heat structures and the representation of non-vertical heat slabs in the containment portion of the TRACG model, which has only vertical heat slabs. It should be mentioned that most containment internal heat structures other than a few vertical wall heat slabs in the ESBWR design were conservatively ignored. The heat transfer correlations used for containment modeling are discussed in the response to RAI65.

Q307.2. In Section 7.11, it is stated that the Uchida correlation is available as an option for a lower bound for condensation, which would be consistent with guidance provided in Standard Review Plan. Is this option used in the calculations?

R307.2. Yes, the Uchida correlation is available as an option for a lower bound for condensation. However, this option is not used in the base case calculation. Results of sensitivity study show that the impact of using this option on the long-term DW pressure is small, about +0.2 psi.

In general, the vertical heat slabs have a very small impact on both the short-term and long-term DW pressure. Sensitivity studies were performed by changing the surface areas of the vertical heat slabs in the DW/WW wall and the WW outer wall. [[

]] In summary, the impact of condensation modeling on peak DW pressure is small, especially in comparison to the margin to the design pressure [[

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Q310. Provide plots similar to Figures 3-7-2 through 3.7-15 in Section 3 of NEDC-33083P but for the time frame 0 to 500 seconds and for the time frame 0 to 3600 seconds. These plots will provide a means to assess the containment modeling on the short term (blowdown and early gravity driven cooling system (GDCS) injection periods).

R310. A set of plots from the Containment/LOCA Base Case and Bounding Case is attached here as Figures 310-1 to 310-13.

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Q317. The TRACG containment models utilize the same conservation equations and constitutive correlations as applied to the reactor system models, i.e., the code, which was initially developed to model the BWR primary coolant system, is currently being used to model the full plant, including the containment. In addition, many of the models have identified errors and uncertainties associated with their use for the containment evaluation. Further the TRACG nodalization models are prescribed to account for additional shortcomings in TRACG to treat some important features, like mixing and stratification in the containment. Some of these prescribed models are based on expected performance (engineering judgement) or the results from small-scale experiment. Typically, containment codes are assessed against a large body of experimental tests (both separate effects and integral tests) designed to address containment performance. In addition, when a new code is proposed for use, an applicant provides a comparison to its currently acceptable code as a benchmark to aid in understanding the results and identifying important features or phenomena in the new methodology.

Q317.1. Provide a plan and schedule to assess the ability of TRACG to model containment performance against integral tests. Integral tests that should be considered include the Marviken tests, the Carolinas Virginia Tube Reactor (CVTR) test 3 without sprays, and the Battelle-Frankfurt Model Containment (BFMC) tests C-13 and C-15 for main steam line breaks. The TRACG results should be assessed against available results from other computer program results (GOTHIC, CONTAIN, etc.).

R317.1. GE agrees to perform assessment of TRACG to model containment performance against integral test data that is publicly available for Standard Problems where the test facilities and tests are well defined. The tests to be analyzed will be specified later, and the analysis will be completed during the design certification phase of the program. GE prefers to compare TRACG calculated results directly to the data rather than to other computed results.

Q317.2. Provide a plan and schedule to assess the ability of TRACG to model containment performance against separate effect tests. Separate effects tests that should be considered include the Wisconsin Flat Plate condensation tests (Huhtiniemi, I.K. and Corradini, M.L., "Condensation in the Presence of Noncondensable Gases," Nuclear Engineering Design, 141, pp.429-446, 1993), M. Siddique, "The Effects of Noncondensable Gases on Steam Condensation Under Forced Convection Conditions," MIT, January 1992, and K. Liang, "Experimental and Analytical Study of Direct Contact Condensation of Steam and Water," MIT, May 1991. The TRACG results should be assessed against available results from other computer program results (GOTHIC, CONTAIN, etc.)

R317.2. GE agrees to perform assessment of TRACG to model containment performance against separate effects test data that is publicly available for Standard Problems where the test facilities and tests are well defined. The tests to be analyzed will be specified later, and the analysis will be completed during the design certification phase of the program. GE prefers to compare TRACG calculated results directly to the data rather than to other computed results.

Q317.3. Provide a plan and schedule to assess TRACG against the previously accepted GE codes used for containment performance evaluations, M3CPT and SHEX. These comparisons need not extend beyond the time of GDCS injection.

R317.3. TRACG comparisons against Mark II and Mark III blowdown tests (which were also the basis of M3CPT assessment) are judged to be sufficient for assessment of TRACG for the blowdown phase of the ESBWR LOCA transient.

Q321. Please augment the discussion presented in Section 3.3.1.1.1 of NEDC-33083P, "TRACG Application to ESBWR," to include the safety relief valves (SRVs). Provide a revised Figure 3.3-1 including the location of the SRV release point into the suppression pool. In the augmented discussion, using the modified figure as a reference; describe what happens in the model as the flow in each main vent stops. For example, when the lower main vent closes, what happens to the interface between the stacked cells (at ring 5 between level 2 and level 3, at ring 6 between level 2 and level 3) as well as what happens to the radial cell interfaces (level 2 between ring 5 and ring 6). Take the discussion through the time when the upper main vent flow stops. What happens to the energy from the SRVs? What cells are considered in the stratification model to account for the SRVs?

R321. Section 3.3.1.1.1 which discusses the suppression pool stratification model has been supplemented to account for the SRV discharge as shown below to address this RAI. Similarly, Figure 3.3-1 has been modified as shown in the attached figure. **Additions are shown in bold.**

3.3.1.1.1 Suppression Pool Stratification

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Q324. It was stated on page 2-38 of NEDC-33083P that the minimum chimney water level occurs at about 10 to 12 hours after the break. However all the ECCS LOCA cases documented in the report stop at 2000 seconds. Please provide a conservative GDCS LOCA calculation to demonstrate that the two-phase water level remains above the core beyond 12 hours after the break. When performing the calculation, consider using 102% power, the correct scram time and other conservative assumptions.

R324. A GDCS LOCA calculation was performed at 102% power with other conservative assumptions. In this case, reactor scram was initiated on High DW pressure, and reactor power started to shutdown after an appropriate delay time. Figure 324-1 shows the comparison of static head in chimney and downcomer collapse level. The core is covered and remains covered by more than [[ ]] of 2-phase mixture for the entire transient (0 ~ 7 hours). Consequently, there is no core heatup. At the end of this transient, the static head in chimney reaches the quasi-steady level of [[ ]] Please refer to RAI 323.5 for additional discussion of level responses beyond 7 hours.

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Q326. According to the ESBWR design description, the GDCS pool air space is connected to the suppression pool air space through three large diameter vent pipes. Therefore, the pressure should be equalized during normal operation. However, TRACG calculated a higher GDCS pool air space pressure than the suppression pool pressure due to the simplified GDCS pool nodalization. This unrealistic pressure results in a higher initial inventory of air in the GDCS space. Please explain the effect of this nodalization on the calculated ECCS performance and, ultimately, the minimum chimney two-phase water level.

R326. TRACG uses a staggered mesh in which the momentum equation is integrated from cell-center to cell-center. The cell pressure is calculated at the center of the cell. [[

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Q329. It has been repeatedly stated that the ESBWR has significant margins for LOCA since the calculated two-phase water level by TRACG is always above the top of active fuel. The TRACG 3-D vessel two-phase water level tracking algorithm has been used to calculate the two-phase water level location in the chimney region during GDCS LOCA transient. The underlying assumption of this level tracking algorithm is that within each cell, there are no flow restrictions. However the entire core is not under a single chimney partition. The two-phase water level in the chimney is expected to be vary. The TRACG 3-D vessel model numerically averages the two-phase mixture level in three radial rings. Please provide justification or demonstrate through sensitivity runs that the TRACG code is capable of calculating the minimum two-phase water level considering the chimney partition and bundle power distributions for GDCS LOCA.

R329. The TRACG nodalization used for the ECCS/LOCA analysis employs three vessel rings to represent the large number (~ 60) of chimney cells in the reactor vessel. Each chimney partition cell in the ESBWR receives flow from 16 fuel bundles (4 x 4 array) and the bypass region associated with those bundles. Thus, the calculated two-phase level in each ring of the TRACG model represents the average of the chimney two-phase levels for all the partition cells represented by that ring. In order to assess the effect of modeling a localized chimney cell above a high-power cluster of 16 bundles, one can examine the sensitivity of the two-phase levels in the three TRACG rings representing chimney cells, each fed by a corresponding group of bundles, to the bundle radial peaking factors. Accordingly, a study was performed to examine the effect of bundle power distribution on the minimum chimney water level.

The baseline case (GDCS line break) was used for the study. The same radial peaking factor was applied to all the bundles in a given ring. The radial peaking factor for all 194 bundles feeding the chimney region in Ring 1 was set equal to 1.43. The other radial peaking factors were 1.00 for the 492 bundles feeding the chimney region in Ring 2 and 0.75 for the 336 bundles feeding the chimney region in Ring 3. The minimum static heads in the chimney regions in Rings 1, 2 and 3 for this parametric case are [[ ]]

The result of this study shows that the impact of assigning a uniform high radial peaking to all the bundles feeding the chimney region in Ring 1 is less than [[ ]] on the chimney minimum static head, or less than [[ ]] of the margin in the minimum static head. Therefore, the TRACG code with the current representation of the ESBWR chimney (Figure 2.7-1) and bundle power distribution is judged to be adequate for calculating the minimum two-phase water level for a GDCS LOCA.

Q331. Please provide the material properties and dimensions of the vessel wall, vessel thermal insulation layer, air gap and vessel shield. Justify why these components are lumped into one heat structure.

R331. The following provides the necessary information about the vessel, thermal insulation, and shield wall.

RPV:
Wall thickness = Nominal 184 mm (including cladding)
Wall material – Either plate or forgings of SA-533, Grade B, Class 1 for plate and SA-508, Class 3 for forgings

Insulation:
Insulation is approximately 90 mm thick of the reflective type, with thin inner sheets separated by air gaps. The insulation stands off from the vessel wall about 250 mm. The average heat transfer coefficient is 0.907 W/m^2K

Vessel shield wall is 160 mm thick made of low alloy structural steel.

Please refer to RAI 12 for the answer to part 2. of the question

Q387. Pages 2-113 (1st paragraph) and 2-119 (Table 2.6-2). As stated, the initial test conditions for the GIRAFFE/SIT tests approximate the SBWR conditions when the RPV pressure reaches 150 psia.

Q387.1. What was the basis for the initial test conditions in Table 2.6-2?

R387.1. The initial test conditions in Table 2.6.2 were based on TRACG runs for the SBWR. The conditions at 1.034 MPa were selected for the initial conditions of the tests.

Q387.2. Compared to three other GDLB tests, Test GS3 (BDLB) had the highest initial DW and WW pressures, but it had the lowest initial SP water temperature. Why didn't Test GS3 have the highest initial SP temperature?

R387.2. Please see the response to RAI 387.1, which describes the basis for the initial conditions for the tests. [[

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Q388. Page 2-113, last paragraph. As stated, data from Test GS3 were examined to identify any potential systems interactions associated with the IC and PCC operation for a BDLB. How was this done? Was there a similar BDLB test but without the isolation of the ICs and PCCS operation for comparison?

R388. [[

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It has been indicated that the ESBWR core would never be uncovered during a loss-of-coolant accident (LOCA) since the two-phase water level is always above the top of active fuel region. The staff performed a confirmatory analysis using TRACG V4.0 and gravity-driven cooling system (GDCS)/LOCA input deck provided by General Electric (GE). The calculated results show that the hot channel, which is modeled by CHAN0011, experiences high void fraction flow for a period of 30 seconds starting from 400 seconds into the GDCS/LOCA event. The maximum channel inlet and outlet void fractions are 0.96 and 0.98 respectively, while the void fraction in the heated region is about 93 percent. Therefore, part of the core is uncovered for a short period of time. A tele-conference was held on July 29, 2003, between the NRC staff and GE representatives regarding this issue. The following are GE's verbal positions:

GE also predicted the same high void flow using TRACG V4.0 code for the GDCS/LOCA case.

- GE believes that [[

]] This is no different from operating BWR LOCA phenomenon.

- GE believes that [[
]] no dryout would occur during the blowdown.

GE indicated that [[

]] However, [[
]] during the blow-down phase.

GE believes that the TRACG code has the capability to predict critical heat flux for high void flow in the core and the [[
]] the boiling transition.

- GE believes that the ESBWR fuel rod surface will not experience boiling transition [[ ]] occurs during the blowdown.

The staff requests GE to respond to the following questions and provide necessary justifications and technical basis:

Q406. Three LOCA cases have been analyzed by GE so far. They are the GDCS Line LOCA, Main Steam Line LOCA and bottom drain line LOCA. Please calculate the duration of the hot channel high void flow for all three cases using conservative approaches, i.e, 102 percent initial power level, delayed scram, 2 uncertainty for correlations leading to a higher void fraction and a longer duration

of high void flow, hot channel bundle power peaking factors, etc. Please model the chimney partition above the hot channel appropriately.

R406. Results of the Scoping Break Spectrum Analysis (Table 2.4-2, NEDC-33083P, TRACG Application for ESBWR) show that the GDCS line break with one GDCS injection valve failure is the limiting case. Accordingly, this limiting case was analyzed to determine the duration of the hot channel high void flow. This case was performed with 102% initial power and other conservative assumptions. Reactor scram was initiated on high drywell pressure, and reactor power started to shutdown after an appropriate delay time. The effect of chimney partition above the hot channel was modeled the same way as that discussed in RAI 329. In this extreme case, the radial peaking factor for all the bundles feeding the chimney region in Ring 1 was set equal to 1.43. Results of this case show that the peak void fraction is [[ ]] and occurs at about 564 seconds for the hot channel. The duration of channel exit void fraction above [[ ]] seconds. No core heatup was calculated for this case.

Q408. What is the basis to define the hot channel power peaking factor as [[ ]]? Have any sensitivity analyses been performed to address the impact of the axial power shape and hot rod power peaking factor? If so, please provide the reults of the sensitivity analyses.

R408. BWR cores are not restricted to a maximum value of the radial peaking factor. Two thermal limits have to be satisfied: the Peak Linear Heat Generation Rate (PLHGR) for the fuel design and the Minimum Critical Power Ratio (MCPR) for the limiting Anticipated Operating Occurrence (AOO). The specification of these criteria allows the core designer to optimize the fuel design and core operation. [[

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