GE Nuclear Energy

A.S. Rao
Project Manager, ESBWR

General Electric Company
175 Curtner Avenue, M/C 365 San Jose, CA 95125-1014
408 925-1885 (phone) 408 925-6462 (facsimile)

Project 717

MFN 03-057
July 31, 2003

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: **Response to Request for Additional Information (RAI) numbers (9, 16–24, 113–143, 213, 214, 234, 236, 257, 258, 266, 275, 276, 279, and 281) for ESBWR Pre-application Review.**

GE Nuclear Energy is submitting, in enclosures 1 and 2, responses to Requests for Additional Information (RAI) numbers 9, 16–24, 113–143, 213, 214, 234, 236, 257, 258, 266, 275, 276, 279, and 281 included in the Referenced letters.

Enclosure 1 contains proprietary information as defined by 10CFR2.790. GE customarily maintains this information in confidence and withholds it from public disclosure. A non-proprietary version of the response to the NRC's request is 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.

Sincerely,

ASRao

Atambir S. Rao

D068

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)

Enclosures:

1. MFN 03-057 Responses to RAI numbers (9, 16–24, 113–143, 213, 214, 234, 236, 257, 258, 266, 275, 276, 279, and 281) - Proprietary Information
2. MFN 03-057 Responses to RAI numbers (9, 16–24, 113–143, 213, 214, 234, 236, 257, 258, 266, 275, 276, 279, and 281) - Non-proprietary Information
3. Affidavit, George B. Stramback, dated July 30, 2003

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

General Electric Company

AFFIDAVIT

I, George B. Stramback, state as follows:

(1) I am Manager, Regulatory 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 03-057, Atambir S. Rao to NRC, *Response to Request for Additional Information (RAI) numbers (9, 16–24, 113–143, 213, 214, 234, 236, 257, 258, 266, 275, 276, 279, and 281) for ESBWR Pre-application Review*, dated July 30, 2003. The proprietary information is in Enclosure 1, *Response to NRC RAI numbers (9, 16–24, 113–143, 213, 214, 234, 236, 257, 258, 266, 275, 276, 279, and 281).* 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 that cannot be appropriately identified as proprietary with the double underlined font are identified with large brackets. 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 contains the computer code and other input decks 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 31th day of July 2003.

George B. Stramback

George B. Stramback
General Electric Company

ENCLOSURE 2

MFN 03-057

Response to NRC RAI numbers (9, 16–24, 113–143, 213, 214, 234, 236, 257, 258, 266, 275, 276, 279, and 281)

Non-Proprietary

Q9. Please provide a large scale drawing of the ESBWR vessel and the vessel internals with major dimensions and elevations.

R9. The following figures and table provide the major dimensions and elevations of the ESBWR vessel, internals and containment.

Figure 9.1. ESBWR Reactor Key Features

Figure 9.2. ESBWR RPV with 10 ft Fuel

Figure 9.3. ESBWR Lower Plenum with 10 ft Fuel

Figure 9.4. ESBWR Sectional View ($90^{\circ} – 270^{\circ}$)

Figure 9.5. ESBWR Sectional View (0° – 180°)

Figure 9.6. ESBWR Horizontal Vent System

Table 9.1. Summary of Key Volumes (See Figure 7 for Location)

Figure 9.7. Location of Key Volumes in Table 1

Q16. Abbreviation error :
In page 1-1 of the ESBWR Scaling report (NEDC-33082P), 2nd line of last paragraph should be "SBWR," not "ESBWR."

R16. GE agrees. The sentence should read "SBWR." The change will be incorporated into the next revision of the report.

Q17. Please add the PCCS vent submergence to "ESBWR Horizontal Vent System" figure. Is the top elevation of the suppression pool gas volume (i.e., lower surface of diaphragm floor between DW and WW) at 16900 mm? And, please provide a figure showing the top view (including azimuthal and radial locations of the 10 vertical vent pipes) of the horizontal vent system with radial dimensions.

R17. The top elevation of the suppression pool gas volume is at 16900 mm. Figures 17.1 and 17.2 provide additional information on the PCC vent exit and the top view of the vent pipes. For the main steam break case, the suppression pool collapse level following the blowdown is at an elevation of [[ ]] from the RPV bottom.

Figure 17.1. Horizontal Vent System and PCC Vent Pipe
(Note: All elevations and dimensions are tentative pending detail design)

Figure 17.2. Horizontal Vent System (Top View)
(Note: All dimensions are tentative pending detail design)

Q18. Please provide a table listing the height (in reference to the inner surface of pool bottom) of Isolation Condenser (IC)/PCCS pools, the normal water level in these pool, the elevation of the top of the condenser tubes (or the bottom elevation of the top header), the normal "total water volume" in the IC/PCCS pools (with the presence of IC and PCC condensers), and the maximum water volume filling to the top of the pools with the presence of IC and PCCS condensers.

R18. Figure 18.1 shows the height and elevations. The ID of lower and top headers of PCC is [[ ]]. Figure 18.2 shows the water volumes in various pools.

[[ ]]

Figure 18.1. ESBWR PCC Pool
(Note: All elevations and dimensions are tentative pending detail design)

Figure 18.2. Total Water Volume available for IC/PCC HXs [[ ]]
(Note: All elevations and dimensions are tentative pending detail design)

Q19. Does Volume 0 communicate freely with Volume 1 in the "Location of Key Volumes in Table 1," figure? What is the rationale or advantage to separate these two volumes? Will the loss-of-coolant accident (LOCA) break flow and the condensed steam on the drywell wall fill up Volume 0 first and then Volume 2 next?

R19. Volume 0 communicates freely with Volume 1. The Vessel Zero elevation is chosen as one of the axial "Levels" in the TRACG nodalization. The free air volumes in Volumes 0 and 1 are calculated accordingly. In the case of LOCA, condensate and liquid from breaks will fill up lower volumes first, in the order of Volume 0, 1 and 2.

Q20. Please provide a sketch showing how a fuel assembly is supported on the core plate and the various leakage paths between fuel assemblies and the bypass region of the ESBWR.

R20. Figure 20.1 shows the Standard BWR bypass leakage paths. Figure 20.2 shows "F" lattice bypass leakage paths for ESBWR. Figure 20.3 shows the "F" lattice core plate partial section view, and Figure 20.4 shows "F" lattice core plate isometric – partial section view.

Figure 20.1. Standard BWR Bypass Leakage Paths

Figure 20.2. "F" Lattice Bypass Leakage Paths

Figure 20.3. "F" Lattice Core Plate Partial Section View

Figure 20.4. "F" Lattice Core Plate Isometric – Partial Section View

Q21. Provide instrumentation diagrams for the RPV that show all the safety-related instrument locations for measuring pressures, temperatures, water levels (or differential pressure), and gas concentrations in the RPV (for initiating reactor scram and containment isolation). Show Levels 0.5, 1, 2, 3, 8, and 9, normal water level, top of active fuel (TAF), and bottom of active fuel (BAF).

R21. These instrumentation diagrams will be submitted as part of the SAR. The current design information has only been submitted as a reference for review of the analysis methods and testing. The DW and WW instrumentations are design issues and are not part of the current NRC review scope.

Figure 21.1 and Table 21.1 show the RPV levels and setpoints. These values are tentative pending detail design.

Figure 21.1. ESBWR Water Levels

Table 21.1. Summary of ESBWR RPV Levels*

* analytical limits shown for all level setpoints

Q22. Will Level 9, Level 3, Level 2, Level 1, or Level 0.5 initiate a reactor scram if reactor is not yet scrammed? Please explain the logic for the Level 2 initiation of a joint automatic depressurization system (ADS) inhibit plus standby liquid control system (SLCS) initiation with a concurrent "APRM Not Downscale" signal.

R22. The reactor will scram and isolate when the water level rises to Level 8 position that is below the Level 9 elevation. Similarly, the reactor will scram when the water level drops to Level 3 position that is above the Level 2 elevation.

Q23. After Level 1 is confirmed, describe the actuation sequence and time delay of 12 safety relief valves (SRVs), 8 depressurization valves (DPVs), 8 gravity driven cooling system (GDCS) injection valves, and 4 PCCS drain tank valves.

R23. The actuation sequence and time delay are summarized in Table 23.1. These values are tentative pending detail design. The SRV distribution is as follow. Each main steam line connects to 3 SRVs. Main steam lines # 1 and # 3 have 1 SRV with 0.0 second delay time and 2 SRVs with 10. seconds delay time. Main steam lines # 2 and # 4 have 2 SRVs with 0.0 second delay time and 1 SRV with 10. seconds delay time.

Table 23.1. Actuation sequence and delay time for ADS and GDCS valves

Q24. How many nozzles does the RPV have? What are the inside diameters of each nozzle?

R24. Table 24.1 summarizes the ESBWR RPV nozzles and LOCA break areas.

Table 24.1. Summary of ESBWR RPV Nozzles and LOCA Break Areas

ESBWR RPV Nozzles and LOCA Break Areas

Chapter 2. PANDA Transient Tests P1

Q113. The document reviewed does not include the information regarding the physical dimensions of the PANDA test facility. Please provide a reference that contains the relevant dimensions of the various components (vessels, tanks, heat exchangers, pressure differential to open vacuum breaker, etc.) of the facility. Please also provide the scaling ratios (vs. ESBWR) of the individual components (or any deviations from 1/45 ratio).

R113. The PANDA test facility dimensions are given in Reference 1, which was transmitted to the NRC via a letter to Joseph Sebrosky, dated August 16, 2002. The basic dimensions of the facility have not changed since that document was issued, although the vessel connections were modified to reflect the ESBWR configuration as described in References 2 and 3. For scaling comparisons, it is the parameter groups identified as "PI-groups" in the scaling report that are important rather than individual parameters. The PI-groups for ESBWR and PANDA are compared in Reference 4. The numerical values required to calculate ESBWR-to-PANDA ratios of individual parameters are given in Reference 5 but the ratios are not listed since they are not as relevant to the scaling comparison as the PI-groups.

References

1. *PANDA Facility, Test Program and Data Base General Description (DTR Umbrella Report)*, Alpha-606-0, PSI, May 1996 (Non-Proprietary).
2. *ESBWR Test Report*, NEDC-33081P, August 2002 (Section 2.2).
3. *ESBWR Scaling Report*, NEDC-33082P, Rev 0, December 2002 (Section 5.5).
4. Ibid. (Section 8).
5. Ibid. (Appendix A).
6. *TRACG Qualification for SBWR*, NEDC-32725P, V. 1, Rev. 1, August 2002 (Section 4.1).
7. Ibid. (Section 4.3)
8. *TRACG Qualification for ESBWR*, NEDC-33080P, August 2002.
9. *TRACG Application for ESBWR*, NEDC-33083P, September, 2002 (Section 3.3.1.1.3).
10. Ibid. (Section 3.3.1.1.1).
11. Ibid. (Section 3.3.1.1.2).
12. *TRACG Qualification for SBWR*, NEDC-32725P, V. 1, Rev. 1, August 2002 (Appendix B).
13. *TRACG Application for ESBWR*, NEDC-33083P, September, 2002 (Figure 3.7-2).

Q114. One of the main purposes of the PANDA tests was to support the use of TRACG to model the post-LOCA behavior of ESBWR containment. However, the nodalization of the PANDA test facility (Figure 2-3 of NEDC-33080P) is substantially different from that of ESBWR (presented in Figure 2-2 of NEDC-33080P and Figure 2.7-1 of NEDC-33083P, TRACG Application for ESBWR). For example, azimuthal nodalization of the VESSEL component was utilized to represents various components in PANDA, while radial nodalization was utilized to model them in ESBWR.

R114. The nodalizations used for PANDA and for the ESBWR are not substantially different. They appear different because the PANDA nodalization models the different pressure vessels as two-ring sectors while the ESBWR model uses two complete rings to model the corresponding regions. Both of these nodalizations preserve rotational symmetry so there is no difference between using a sector or a complete ring. The PANDA facility, with its paired DW and WW vessels, was specifically designed to investigate the effects of asymmetry on the operation of the passive safety systems and, while PANDA is a scaled version of the ESBWR in terms of volumes and elevations, there are some nodalization differences that result from inherent geometric differences. However, the nodalizations of both PANDA and the ESBWR use a similar level structure and the numbers of cells used to represent corresponding region volumes are similar. There are differences in the level structure where boundaries are modeled, but the overall nodalization approach between the two is similar. The use of two rings of the TRACG VSSL component for the modeling of the RPV, DW, WW, GDCS pool and PCCS pools in both PANDA and the ESBWR is a key similarity. Two rings is the minimum required to represent an upflow/downflow circulation pattern within the vessels.

Q114.1. Was there any attempt to use similar nodalizations between the ESBWR and PANDA simulations? If not, please explain why these differences should not be an issue in using the PANDA analytical results to validate the TRAC simulation of the ESBWR analysis, considering that nodalization is an important element of the validation.

R114.1. The nodalization used for PANDA does attempt to follow the important characteristics of the nodalization used for the ESBWR. As noted above, there are many similarities between PANDA and the ESBWR models, particularly with respect to the radial and axial nodalizations of the PANDA vessels representing the ESBWR RPV, DW, WW, GDCS and PCCS pools. The ESBWR represents the WW with a single azimuthal sector and two rings while the two PANDA WW vessels are each represented by a single sector and two rings. (An objective of the PANDA test program was to demonstrate the adequacy of the axisymmetric modeling of the DW and WW in the ESBWR.) The same numbers of cells and levels are used for the liquid and vapor regions in each of the PANDA WW vessels as are used to model the wetwell pool

and air-space in the ESBWR. A similar strategy is used to model the DW, although the ESBWR DW runs the full length of the model and, consequently, has more levels than the PANDA DW. Again, two rings and a single sector are used for the ESBWR DW and for each of the PANDA DW vessels. The level and cell arrangement in the PCC pools and the nodalization of the condensers themselves are the same in both the ESBWR and PANDA TRACG models. The RPV nodalization in both the ESBWR and PANDA models has two rings and a similar number of levels. For both nodalizations, the cells which represent the various volumes in the model are arranged in several levels with two rings and, as there are no lateral or azimuthally connected cells, the same form of the governing equations is used to calculate flow between cells. The nodalization differences between the two models are believed to be superficial and substantially outweighed by the similarities.

Q114.2. In view of the importance of the noncondensible gas distribution in DW and its potential impact on the PCCS performance, the nodalization of the DW is of considerable interest. Both in PANDA and ESBWR, the DW is modeled with four axial nodes. However, the DW in PANDA is represented by two radial rings and also includes two small axial nodes (to represent the connecting pipes) in the middle, while the DW in ESBWR is represented by four radial rings with relatively evenly distributed four axial nodes. It seems that these are quite dissimilar nodalizations. Please discuss the possible impact of this nodalization difference in using the PANDA analyses for the validation of TRACG code. Does this imply that the DW nodalization would not be a significant factor?

R114.2. The responses presented earlier in this section have pointed out that both the PANDA and ESBWR nodalizations employ two rings (not four) to model all major regions in the containment. The two relatively short axial cells in the PANDA DW model are specifically related to the DW connecting pipe. This is a PANDA-unique feature that facilitated the simulation of asymmetric effects and their potential impact on the performance of the PCCS. There would be no technical basis for replicating this aspect of the nodalization in the ESBWR model. [[

]] The objective of the PANDA TRACG qualification was to confirm the adequacy of the code in a realistic application framework. Accordingly, the DW nodalization was chosen to be representative of the region of the ESBWR DW represented in PANDA with no special component to ensure noncondensable holdup. Delayed release of noncondensable in PANDA was addressed by Tests P4 and P5.

Q114.3. The heat transfer in the poolside film may be a significant factor to determine the PCCS capability to remove heat. Please discuss the nodalization of the PCCS pool (it is not clear from the document) and its impact on the heat transfer in the outside surface of the PCCS pipes. The discussion should include the number of radial cells used and the effect of nodalization on the internal natural circulation and heat transfer in the pool (vs. using one cell radially). Were there any measurements which will help to determine the pool side heat transfer coefficients? List any tests or studies to validate this model/nodalization. Were there any sensitivity calculations regarding the pool side nodalization? Was the variation between parallel tubes accounted for? Was the changing level elevation accounted for in calculating the heat transfer coefficients (or effective heat transfer area)? Is the same nodalization used for ESBWR?

R114.3. The PCC pool and condenser modeling used for both PANDA and the ESBWR were verified against extensive component test data, including [[

]] In these tests, the pool-side and gas-side heat transfer modeling as well as the pool, condenser tube and header nodalizations were verified by comparisons to data over a range of conditions simulating those expected in the post-LOCA transient. The PANTHERS comparisons included a [[

]] Both the PANDA and ESBWR TRACG simulations account for the pool level decrease associated with boiloff and its effect on the poolside heat transfer coefficient and the effective condenser heat transfer area.

References

1. *PANDA Facility, Test Program and Data Base General Description (DTR Umbrella Report)*, Alpha-606-0, PSI, May 1996 (Non-Proprietary).

2. *ESBWR Test Report*, NEDC-33081P, August 2002 (Section 2.2).
3. *ESBWR Scaling Report*, NEDC-33082P, Rev 0, December 2002 (Section 5.5).
4. Ibid. (Section 8).
5. Ibid. (Appendix A).
6. *TRACG Qualification for SBWR*, NEDC-32725P, V. 1, Rev. 1, August 2002 (Section 4.1).
7. Ibid. (Section 4.3)
8. *TRACG Qualification for ESBWR*, NEDC-33080P, August 2002.
9. *TRACG Application for ESBWR*, NEDC-33083P, September, 2002 (Section 3.3.1.1.3).
10. Ibid. (Section 3.3.1.1.1).
11. Ibid. (Section 3.3.1.1.2).
12. *TRACG Qualification for SBWR*, NEDC-32725P, V. 1, Rev. 1, August 2002 (Appendix B).
13. *TRACG Application for ESBWR*, NEDC-33083P, September, 2002 (Figure 3.7-2).

Q115. The post-test results are presented in Section 2.5. Were there any attempts to do the pre-test or blind calculations? If not, why not? If there were, were any significant differences between the pre- and post-test results observed? Were any parameters adjusted during the post-test analyses? If yes, what were they? Were the same adjustment made to the ESBWR analyses?

R115. Blind pretest calculations were not done for the P-series tests described in Reference 8. Double-blind pretest calculations were done for three of the earlier M-series tests and the steady-state PANDA PCC tests documented in Revision 1 of NEDC-32725P. The M-series pretest calculations predicted the peak DW pressure within [[ ]] The pretest calculations indicated that the prediction of WW temperature could be improved by reducing the vapor space nodalization from [[

]] This change was incorporated for the M-series post-test calculations and was also implemented in the E/SBWR containment model. At the close of the M-series post-test calculations, it was concluded that certain procedures should be implemented in the application methodology for E/SBWR containment calculations to ensure adequate consideration of the potential implications of mixing and stratification in large containment volumes. These procedures [[

]] The M-series post-test calculations also indicated that the TRACG PANDA model could be improved by representing the large DW crossover pipe by two TRACG PIPE components that would permit the simulation of back and forth circulation through the connecting pipe. This change, which was unique to the PANDA facility and had no counterpart for the ESBWR model, was incorporated in the TRACG model for the post-test calculation of the P-series tests. The other major change in the TRACG model from the M-series to the P-series was to make the RPV and the PCCS pools part of the TRACG VSSL component. The major reason for this change was to bring the PANDA model into correspondence with the representation of these regions in the ESBWR model. The only change made in the model in the course of the P-series post-test calculations was to raise the inlet to the IC steam line to prevent liquid from entering the line. This change had no implication for the ESBWR model.

References

1. *PANDA Facility, Test Program and Data Base General Description (DTR Umbrella Report)*, Alpha-606-0, PSI, May 1996 (Non-Proprietary).
2. *ESBWR Test Report*, NEDC-33081P, August 2002 (Section 2.2).
3. *ESBWR Scaling Report*, NEDC-33082P, Rev 0, December 2002 (Section 5.5).
4. Ibid. (Section 8).

5. Ibid. (Appendix A).
6. *TRACG Qualification for SBWR*, NEDC-32725P, V. 1, Rev. 1, August 2002 (Section 4.1).
7. Ibid. (Section 4.3)
8. *TRACG Qualification for ESBWR*, NEDC-33080P, August 2002.
9. *TRACG Application for ESBWR*, NEDC-33083P, September, 2002 (Section 3.3.1.1.3).
10. Ibid. (Section 3.3.1.1.1).
11. Ibid. (Section 3.3.1.1.2).
12. *TRACG Qualification for SBWR*, NEDC-32725P, V. 1, Rev. 1, August 2002 (Appendix B).
13. *TRACG Application for ESBWR*, NEDC-33083P, September, 2002 (Figure 3.7-2).

Q116. The time step sizes sometimes influence the results of the calculations. Are the time step sizes of the PANDA analysis similar to those of ESBWR analysis (maximum as well as average)? What was the basis of the time step selections?

R116. TRACG chooses its timestep in accordance with an internal logic that continuously optimizes the accuracy and efficiency of the calculation. The only control imposed by the user is to supply a maximum and minimum timestep. TRACG will not use a timestep larger than the specified maximum and it will stop if its built-in accuracy criteria require it to use a timestep smaller than the specified minimum. In addition, the user may divide the duration of the calculation into segments and vary the specified maximum and minimum timesteps from segment to segment. The ESBWR containment calculation uses a maximum timestep of [[ ]] for the first hour of the simulation and [[ ]] thereafter. The minimum timestep is [[ ]] for the first hour and [[ ]] thereafter. For the PANDA runs, which involved deliberately imposed and relatively abrupt transient changes, the maximum timestep ranged from 0.02 to 0.2 s and the minimum timestep was [[ ]] except for a short period of Test P2 and part of Test P7 where it was reduced to [[ ]] It may also be noted that a timestep sensitivity study performed in conjunction with the SBWR TRACG qualification showed no significant sensitivity to the choice of maximum timestep [12].

References

1. *PANDA Facility, Test Program and Data Base General Description (DTR Umbrella Report)*, Alpha-606-0, PSI, May 1996 (Non-Proprietary).
2. *ESBWR Test Report*, NEDC-33081P, August 2002 (Section 2.2).
3. *ESBWR Scaling Report*, NEDC-33082P, Rev 0, December 2002 (Section 5.5).
4. Ibid. (Section 8).
5. Ibid. (Appendix A).
6. *TRACG Qualification for SBWR*, NEDC-32725P, V. 1, Rev. 1, August 2002 (Section 4.1).
7. Ibid. (Section 4.3)
8. *TRACG Qualification for ESBWR*, NEDC-33080P, August 2002.
9. *TRACG Application for ESBWR*, NEDC-33083P, September, 2002 (Section 3.3.1.1.3).
10. Ibid. (Section 3.3.1.1.1).
11. Ibid. (Section 3.3.1.1.2).
12. *TRACG Qualification for SBWR*, NEDC-32725P, V. 1, Rev. 1, August 2002 (Appendix B).

13. *TRACG Application for ESBWR*, NEDC-33083P, September, 2002 (Figure 3.7-2).

Chapter 2. PANDA Transient Tests P1

Q117. In almost every test (except P3), the drop in the DW pressure and decrease of the DW-WW pressure difference (sometimes negative) were observed in the initial phase of the tests. After this initial period, the Δp remained steady for most of the tests (except P2, where a repetition of this pressure drop was observed). Please clarify the discussion in Section 2.5.1.1 regarding the effect of the amount of PCCS heat removal.

R117. The characteristic behavior at the start of the PANDA tests was a rise in the DW pressure due to [[

]] At the end of the initial purging transient, the PCCS [[

]]

Q117.1. Should this phenomenon repeat periodically, since the excess heat removal capability still exists?

R117.1. An important operating characteristic of the PCCS is [[

]] If the heat removal capacity of the system falls below the DW heat load, [[

]]

Q117.2. If the high heat removal capacity reduces the Δp, shouldn't the PCCS heat removal and Δp balance eventually at some equilibrium? (It should be noted that the PCCS inlet flow rates in Figure P1/8-3 and the PCCS heat removal in Figure P1/8-2 did not decrease markedly during this period when the Δp decreases.)

R117.2. The flow to the condenser units is [[

Chapter 2. PANDA Transient Tests P1

]]

Figure 117.2.1. TRACG Pressure Differences for PANDA Test P4

Q117.3. The DW pressure drops happened at considerably different times for the test and the analysis for some tests, (about 12000 and 8000 sec for P1, 7000 and 13000 seconds for P2, 22000 and 12000 sec for P6). It happens earlier for test than analysis for some tests, and later for some other tests. Please discuss how this discrepancy and inconsistency will affect the ESBWR DW calculation.

R117.3. TRACG had a varying degree of success in predicting the timing of the first VB opening. The results ranged from [[

]] The integrated energy removal by the PCCS will match the decay heat input over the long term even though there are intermediate periods where the heat removal exceeds or lags behind the decay heat.

Q117.4. Were similar drops in the DW pressure and Δp also observed in this period in the ESBWR analysis?

R117.4. Yes. The ESBWR post-LOCA containment pressure response shows similar drops in the DW pressure. Typically, about [[

]] are observed in the course of a 72-hour ESBWR analysis [13].

References

1. *PANDA Facility, Test Program and Data Base General Description (DTR Umbrella Report)*, Alpha-606-0, PSI, May 1996 (Non-Proprietary).
2. *ESBWR Test Report*, NEDC-33081P, August 2002 (Section 2.2).
3. *ESBWR Scaling Report*, NEDC-33082P, Rev 0, December 2002 (Section 5.5).
4. Ibid. (Section 8).
5. Ibid. (Appendix A).
6. *TRACG Qualification for SBWR*, NEDC-32725P, V. 1, Rev. 1, August 2002 (Section 4.1).
7. Ibid. (Section 4.3)

8. *TRACG Qualification for ESBWR*, NEDC-33080P, August 2002.

9. *TRACG Application for ESBWR*, NEDC-33083P, September, 2002 (Section 3.3.1.1.3).

10. Ibid. (Section 3.3.1.1.1).

11. Ibid. (Section 3.3.1.1.2).

12. *TRACG Qualification for SBWR*, NEDC-32725P, V. 1, Rev. 1, August 2002 (Appendix B).

13. *TRACG Application for ESBWR*, NEDC-33083P, September, 2002 (Figure 3.7-2).

Chapter 2. PANDA Transient Tests P1

Q118. For tests P1 and P2, substantial Δp between the DW and WW (P1-1a and P2-1a) and flow to PCCS (P1-3 and P2-3) are maintained throughout the tests. This should imply either noncondensible gases or steam is flowing to WW and, therefore, the WW pressure should increase. However, the WW pressure remains constant (P2-1) or declines (P1-1). Please discuss if this observation is correct, and, if correct, please explain why. (Does this mean that there is no Δp between the PCCS and WW, and thus no flow?)

R118. The characteristic state of the PCCS condenser units is [[

]]

The flow into the condenser is [[

]] Over large time periods of the post-LOCA transient, [[

]] Over the long term, however, the amount of noncondensable purged to the WW is [[

]]

Q119. In general, the code does not seem to predict Δp (between DW and WW) very well for the PANDA tests, although it shows good matches for the magnitudes of the pressure and overall heat removal. In view that the Δp is the important variable in determining the performance of PCCS, please discuss how the PANDA results can be used for the validation of TRACG.

R119. Following the initial blowdown and PCCS startup, the PCCS operates [[

]] The PANDA tests confirmed that TRACG correctly simulates [[ ]]

Chapter 2. PANDA Transient Tests P1

Q120. Editorial comments:

Q120.1. Definitions of the TRACG variables in the figures are not provided. While some of variables are obvious, some are difficult to figure out. Some examples are D1L12C1-TR in Figure P1/8-15, or D2L12C2-TR in Figure P1/8-16, etc.

R120.1. The following table describes the notation used for the TRACG variables in all of the comparison plots:

Figure	Notation	Quantity	Location
1	DW1	Pressure (bar)	DW1
1	WW1	Pressure (bar)	WW1
1a	DW-WW	Pressure Difference (bar)	DW1-WW1
2	IC	Power (kW)	IC
2	PCC1	Power (kW)	PCC1
2	PCC23	Power (kW)	PCC23
2	TOT PCC/IC	Power (kW)	Total Condenser Power
3	PCC1	Inlet Flow (g/s)	To PCC1
3	PCC23	Inlet Flow (g/s)	To PCC23
3	IC	Inlet Flow (g/s)	To IC
4	RPV lev	Collapsed Level (m)	RPV
4	GDCS lev	Collapsed Level (m)	GDCS Pool
5	PCC1	Collapsed Level (m)	PCC1 Pool
5	PCC23	Collapsed Level (m)	PCC23 Pool
5	IC	Collapsed Level (m)	IC Pool
6	N/A		
7	IC/UH	Temperature (C)	IC Upper Header
7	IC/C1	Temperature (C)	IC Cell 1
7	IC/C3	Temperature (C)	IC Cell 3
8	IC/C4	Temperature (C)	IC Cell 4
8	IC/C6	Temperature (C)	IC Cell 6
8	IC/C8	Temperature (C)	IC Cell 8
8	IC/LH	Temperature (C)	IC Lower Header
9	P1/UH	Temperature (C)	PCC1 Upper Header
9	P1/C1	Temperature (C)	PCC1 Cell 1
9	P1/C3	Temperature (C)	PCC1 Cell 3
10	P1/C4	Temperature (C)	PCC1 Cell 4
10	P1/C6	Temperature (C)	PCC1 Cell 6
10	P1/C8	Temperature (C)	PCC1 Cell 8
10	P1/LH	Temperature (C)	PCC1 Lower Header
11	P23/UH	Temperature (C)	PCC23 Upper Header
11	P23/C1	Temperature (C)	PCC23 Cell 1
11	P23/C3	Temperature (C)	PCC23 Cell 3

Chapter 2. PANDA Transient Tests P1

Figure	Notation	Quantity	Location
12	P23/C4	Temperature (C)	PCC23 Cell 4
12	P23/C6	Temperature (C)	PCC23 Cell 6
12	P23/C8	Temperature (C)	PCC23 Cell 8
12	P23/LH	Temperature (C)	PCC23 Lower Header
13	Same as Fig. 11		
14	Same as Fig. 12		
15	D1L9C1	Temperature (C)	DW1; Level 9; Inner Ring
15	D1L9C5	Temperature (C)	DW1; Level 9; Outer Ring
15	D1L12C1	Temperature (C)	DW1; Level 12; Inner Ring
15	DIL12C5	Temperature (C)	DW1; Level 12; Outer Ring
16	D2L9C2	Temperature (C)	DW2; Level 9; Inner Ring
16	D2L9C6	Temperature (C)	DW2; Level 9; Outer Ring
16	D2L12C2	Temperature (C)	DW2; Level 12; Inner Ring
16	D2L12C6	Temperature (C)	DW2; Level 12; Outer Ring
17	W1L6C1	Temperature (C)	WW1; Level 6; Inner Ring
17	W1L6C5	Temperature (C)	WW1; Level 6; Outer Ring
17	W1L7C1	Temperature (C)	WW1; Level 7; Inner Ring
17	W1L7C5	Temperature (C)	WW1; Level 7; Outer Ring
18	W1L3C1	Temperature (C)	WW1; Level 3; Inner Ring
18	W1L3C5	Temperature (C)	WW1; Level 3; Outer Ring
18	W1L4C1	Temperature (C)	WW1; Level 4; Inner Ring
18	W1L4C5	Temperature (C)	WW1; Level 4; Outer Ring
18	W1L5C1	Temperature (C)	WW1; Level 5; Inner Ring
18	W1L5C5	Temperature (C)	WW1; Level 5; Outer Ring
19	W2L6C1	Temperature (C)	WW2; Level 6; Inner Ring
19	W2L6C5	Temperature (C)	WW2; Level 6; Outer Ring
19	W2L7C1	Temperature (C)	WW2; Level 7; Inner Ring
19	W2L7C5	Temperature (C)	WW2; Level 7; Outer Ring
20	W2L3C1	Temperature (C)	WW2; Level 3; Inner Ring
20	W2L3C5	Temperature (C)	WW2; Level 3; Outer Ring
20	W2L4C1	Temperature (C)	WW2; Level 4; Inner Ring
20	W2L4C5	Temperature (C)	WW2; Level 4; Outer Ring
20	W2L5C1	Temperature (C)	WW2; Level 5; Inner Ring
20	W2L5C5	Temperature (C)	WW2; Level 5; Outer Ring
21	D1L9C1	Air Partial Pressure (bar)	DW1; Level 9; Inner Ring
21	D1L9C5	Air Partial Pressure (bar)	DW1; Level 9; Outer Ring
21	D1L12C1	Air Partial Pressure (bar)	DW1; Level 12; Inner Ring
21	DIL12C5	Air Partial Pressure (bar)	DW1; Level 12; Outer Ring
22	D2L9C2	Air Partial Pressure (bar)	DW2; Level 9; Inner Ring
22	D2L9C6	Air Partial Pressure (bar)	DW2; Level 9; Outer Ring

Figure	Notation	Quantity	Location
22	D2L12C2	Air Partial Pressure (bar)	DW2; Level 12; Inner Ring
22	D2L12C6	Air Partial Pressure (bar)	DW2; Level 12; Outer Ring
23	VB1-LEAK	VB1 Leakage Flow (g/s)	DW1 to WW1 via VB1

Q120.2. It appears there is an error in Table 2-11 (Page 2-43). The elevation of instrument MTG.D1.2 is denoted as 38 m from tank bottom.

R120.2. The entries for MTG.D1.2 and MTG.D2.2 should be "5.78m from tank bottom".

Q121. In Figure P1/8-1a, when the VB opens, the Δp quickly increased (restored) to the level before the VB opening.

R121. This behavior is typical of the PCCS performance. [[

]]

Q121.1. Please explain why the DW pressure increases above the WW pressure. Is this due to a temporary decrease in the PCCS heat removal capability caused by the noncondensible gases in the DW?

R121.1. Yes. The PCCS heat removal capability is temporarily degraded by the ingestion of noncondensable. The increased pressure allows the condenser units to [[
]]

Q121.2. Why does the PCCS performance deteriorate so much when the noncondensible gas concentration increases very little (Figure P1/8-21 shows the concentration in DW is less than 0.3%, i.e., noncondensible gas partial pressure of 0.005 bar) after the VB opening. Is this an indication of impact of a very small amount of noncondensible gases on the PCCS performance?

R121.2. There are [[

]]

Q121.3. When the vacuum breaker (VB) opened at 12,000 seconds in P1, the noncondensible gas concentration in DW increased slightly (to 0.005 bar) (Figure P1/8-21). However, when the VB opened in P2 (Figures P2-21 and -22), it increased to 0.3 bar. Please explain why the DW noncondensible gas concentration increases are so different between these two tests.

Chapter 2. PANDA Transient Tests P1/8

R121.3. The transients leading to the VB openings in Tests P1 and P2 are [[

]]

Q122. Figure P1/8-2 shows a sustained deficit of the heat removal by the PCCS. Yet, the DW/WW pressures essentially remain constant during the whole test. Please explain why the cumulative effect of this heat removal deficit is not exhibited in the pressure? Wouldn't this eventually be an issue when it continues for 72 hours (259,200 seconds)?

R122. The results shown in Figure P1/8-2 [[

]]

References

1. *PANDA Facility, Test Program and Data Base General Description (DTR Umbrella Report)*, Alpha-606-0, PSI, May 1996 (Non-Proprietary).
2. *ESBWR Test Report*, NEDC-33081P, August 2002 (Section 2.2).
3. *ESBWR Scaling Report*, NEDC-33082P, Rev 0, December 2002 (Section 5.5).
4. Ibid. (Section 8).
5. Ibid. (Appendix A).
6. *TRACG Qualification for SBWR*, NEDC-32725P, V. 1, Rev. 1, August 2002 (Section 4.1).
7. Ibid. (Section 4.3)
8. *TRACG Qualification for ESBWR*, NEDC-33080P, August 2002.
9. *TRACG Application for ESBWR*, NEDC-33083P, September, 2002 (Section 3.3.1.1.3).
10. Ibid. (Section 3.3.1.1.1).
11. Ibid. (Section 3.3.1.1.2).
12. *TRACG Qualification for SBWR*, NEDC-32725P, V. 1, Rev. 1, August 2002 (Appendix B).
13. *TRACG Application for ESBWR*, NEDC-33083P, September, 2002 (Figure 3.7-2).

Q123. Figure P1/8-1a shows Δp is zero around 35,000 sec for the analysis, but Figure P1/8-3 shows a sustained PCCS inlet flow. Please explain what is the driving force for this flow at this time. If this is condensation driven, is this an indication that PCCS does not need Δp (DW-WW) to operate, at least when the noncondensible gas concentration is low?

R123. Yes, the PCCS inlet flow [[

]]

Chapter 2. PANDA Transient Tests P1/8

Q124. For Test P1/8, it appears that the code does not predict the Δp very well in the period of 0-50,000 seconds (the Δp decreased to zero periodically for the analysis, while a sustained Δp was observed in the test after initial dip). In view that the Δp is the driving force of the PCCS (it also impacts on the VB opening, which influence the noncondensible gas concentration in the DW), please discuss how the results of simulation of this test can be used to validate the code.

R124. As stated in the response to RAI 123, [[

]] The PANDA tests (M-series and P-series) demonstrated the validity of this assertion by subjecting the system to a wide range of challenges and showing that the important features of the response (the range of drywell and wetwell pressures and integrated energy removal) could be adequately predicted by TRACG.

Q125. Figure P1/8-5 shows that the PCCS pool level decreases to the lower header upper edge in 100,000 seconds. Is this representative of the ESBWR PCCS pool level in this time period? In view that the ESBWR containment cooling is expected to last 72 hours (259,200 seconds), please discuss why this depletion of pool water is acceptable.

R125. One of the compromises made in the design of the PANDA test facility was to not scale the volume of water available to replace boiloff in the ESBWR PCCS. [[

]] This is more than sufficient to remove the decay heat load.

Q126. The test and calculated gas and liquid temperatures in the WW are substantially different (Figures P1/8-17 through P1/8-20). While the calculated temperatures are constant, the test temperatures are shown to initially increase and then decrease (at around 20,000 seconds for liquid and around 40,000 seconds for the gas).

R126. Please see the responses to the individual questions below.

Q126.1. Please explain this difference between the tests and analyses, discussing why this test can be used for the TRACG validation for ESBWR in spite of this difference.

R126.1. A characteristic of the TRACG simulation of PANDA is to [[

]]

Q126.2. Please explain why the test WW liquid and gas temperatures start decreasing at about 25,000 seconds and 40,000 seconds, respectively, in the test when seemingly nothing else happens.

R126.2. The rise in the WW gas temperature stops at approximately [[

]] The PANDA main vents correctly simulate the ESBWR during the time that there is flow through them from the DW to the suppression pool. [[

]]

Q126.3. Please also explain why the WW gas temperature continues to increase between 20,000-40,000 seconds, while the pool surface temperature starts to decrease at about 25,000 seconds.

R126.3. As described above, the increase in the WW gas temperature was [[

]]

Q126.4. Beyond 40,000 seconds, both the WW gas and liquid temperatures continue to decrease in the test. Where does the energy go during this period (i.e., what cools the WW gas and liquid)?

R126.4. The WW gas is primarily [[

]]

Q127. The purpose of this test is "to examine PCCS behavior and system interactions during the transitional period from the end of blowdown to the initiation of long-term cooling" (Section 2.3.1). However, "the comparison was adversely affected by the leaky check valve," (Section 2.5.2.1) and consequently it appears difficult to derive any conclusions for the period when it was intended to be studied. Please explain why this test is still relevant.

R127. The objective of Test P2 was to demonstrate the PCCS response early in the post-LOCA transient, [[

]]

Q128. In Section 2.5.2.1, measured and calculated DW and WW pressures and the DW-to-WW pressure difference for test P2 are compared in Figures P2-1 and 1a. It is explained that the cause for discrepancies was due to equipment malfunction and that is was not important as calculated pressures were in line with the measurement. However, Figure P2-1a clearly shows a substantially different trend.

R128. While there are differences in the [[

]] overall pressure responses are similar. The major difference is [[

]] The predicted and observed phenomena are similar but the [[ ]]

Q128.1. Please explain this discrepancy between the test and analysis and justify why TRACG is applicable to ESBWR LOCA calculation despite this discrepancy, in view that the Δp is the driving force of the PCCS and also affects the GDCS flow rate.

R128.1. As described in prior responses, [[

]] The driving force for flow to the PCCS from the DW in this period [[

]] Both the test and the TRACG simulation are valid demonstrations of the behavior of the ESBWR during and following the late stage of GDCS injection.

Q128.2. Why does the test Δp rise initially in the test? Since there is no steam generation during this period, it seems the Δp should be near zero.

R128.2. As seen in Figure P2-2, RPV heater power [[

]] It is believed that the brief initial RPV (and DW) pressure rise in the test was [[

]] In this test, the initial RPV conditions [[

]]

Chapter 2. PANDA Transient Tests P2

Q129. Figure P2-1 shows a pressure difference between the DW pressures of the test and calculation in the initial phase (GDCS injection phase), which is substantial at this phase. Therefore, it seems that the code does not simulate this phase very well. Please explain the cause of this difference and discuss the significance of this difference in the TRACG validation.

R129. It is believed that the [[

]] The measurements indicate that [[

]]

Q130. Figure P2-3 shows the PCCS inlet flow and Δp between DW and WW (figure P2-1a) for the calculation. Please explain what is the driving force of this PCCS flow during the period from 5,000 to 13,000 seconds and from 15,000 to 20,000 seconds. Figure P2-3 also shows that the PCCS heat removal rates are similar for the test and calculation, while the Δp's are substantially different between the test and calculation (for example, during 15,000-20,000 seconds). Please explain why the PCCS performance is not affected by the Δp.

R130. The flow to the PCCS in this period is [[ ]] As shown in the figure accompanying the response to RAI 117.2, the [[

]]

Q131. Figure P2-4 shows the calculated level difference between RPV and GDCS at a specified WW-DW pressure difference (Figure P2-1a) and corresponding water level. Since the WW pressure is lower than DW, shouldn't the GDCS tank level be higher than the RPV by at least the same amount? Please explain.

R131. The GDCS tank level is not related to the RPV level by [[

]]

Q132. Figures P2-18 and p2-20 show the WW water surface temperature peaked at about 7,000 seconds and then decreased. Please explain what mechanism contributed to this cooling. On the other hand, the same figures show that the calculated liquid temperature increases steadily. Please discuss what impact this discrepancy would have in using the TRACG for ESBWR analyses.

R132. The rise in the measured WW surface temperature (floating temperature probe) was [[

]]

Q133. Figures P2-21 and P2-22 show steady increases of the noncondensible gas in the DW for the calculation while the noncondensible gas concentration rises quickly and remains at that level for the test. Since the period in which the VB is open is much shorter for the test, it appears that the noncondensible gas flow rate is much higher during the short period when the VB was open for the test. Please compare the noncondensible gas flow rates when the VB are open for the test and calculation and explain the disparity of the flow rates, so the staff can assess how well the TRACG simulates the VB flow rates.

R133. Figures P2-21 and P2-22 compare the air partial pressure from [[

]]

Q134. It is stated in Section 2.5.3.1 that "TRACG's calculation of the air purging rate from DW2 and portions of DW1 above the connecting pipe are in good agreement with the measurements (Figures P3-21 and 22)."

R134. Please see the responses to the individual questions below.

Q134.1. However, Figure P3-22 shows very high degree of stratification of air partial pressure in DW2 for the calculation, while relatively uniform distribution for the test during the initial 10,000 seconds (the period when it matters most in terms of the noncondensible gases). Please discuss how GE drew the conclusion of "good agreement" from this figure.

R134.1. Figure P3-22 shows air partial pressure measurements near the top (MPG_D2_1), in the middle (MPG_D2_2) and at the bottom (MPG_D2_3) of DW2. The measurement locations are close to the vessel centerline. [[

]]

Q134.2. Figure P3-21 and Figure P3-15 show TRACG was unable to simulate the trapped noncondensible gas in DW2. Please explain how this TRACG shortcoming is handled in ESBWR analyses.

R134.2. Figure P3-21 shows comparisons of measured and calculated air partial pressures in DW1, which was isolated in this test. [[

]]

Chapter 2. PANDA Transient Tests P4 and P5

Q135. These tests are intended to investigate the effect on PCCS performance of the delayed release of noncondensible gas from a region of the DW not directly accessible to RPV steam flow. However, the results (test as well as analysis) show that the noncondensible gases are quickly swept to the WW once the injection stops similar to what happens earlier. Then the system repeats similar behavior observed at the beginning of the tests, at slightly higher pressure. In other words, these tests don't seem to provide any more information than obtained in P1. To address the impact of slow seepage (bleeding) of a small amount of noncondensible gases through the PCCS and possible degradation of PCCS capability to remove heat in the presence of these gases, could a small amount of noncondensible gas (in the order of 1% or less) be continuously injected to the DW during the test? Are there any such test data available?

R135. Tests P4 and P5 adequately demonstrate the manner in which the PCCS would respond to the ingestion of a slug of noncondensable at any time during the long-term post-LOCA transient. [[

]]

Chapter 2. PANDA Transient Tests P6

Q136. Test P6 was performed to "consider system interaction effects associated with parallel operation of the ICS and PCCS and the effect of a direct bypass of steam from the DW to the WW air space." Why are these effects combined in one test? Is the bypass of steam more important when the ICS and PCCS operate together? It seems these two unrelated effects make it harder to understand the results.

R136. Test P6 was composed of a [[

]] In addition to information on single and multiple system interactions, it is believed that Test P6 provided a more meaningful challenge for TRACG than would a series of tests involving only single interactions.

Q137. Why does the Δp decrease slower for P6 (Figure P6-1a) compared to P1 (Figure P1/8-1a), when less steam is sent to the DW in P6?

R137. The rate of decrease of the DW pressure is primarily determined [[

]]

Q138. It appears that the Δp decreases to zero at about 20,000 seconds and again at about 40,000 sec (Figure P6-1a) for the test, because of the VB leakage bypassing steam from the DW to the WW. However, Figure P6-2 shows that the PCCS still removes most of the heat at these time periods. What is the driving force of the PCCS flow and why does the PCCS still work when DP=0?

R138. As discussed in the responses to prior questions, the [[

]]

Q139. What was the cause of the sudden blip of Δp for the calculation at about 42,000 seconds, when seemingly nothing else happens? The concern is whether this kind of anomaly may show up somewhere else in the TRACG calculations of ESBWR.

R139. The "blip" in the TRACG DW pressure at about 42,000 s is [[

]]

Q140. Figure P6-23 shows that TRACG substantially over-predicted the VB leakage flow rate during 15,000-25,000 seconds (the period when IC operation and VB opening overlapped), while it gave a good match after 25,000 seconds. Please discuss this inconsistency and its implication in TRACG application to ESBWR. The concern is when to trust the TRACG calculation of the VB leakage rate and when not to.

R140. The VB leakage is [[

]]

Section 2.6 Summary and Conclusions

Q141. In Section 2.6.2.2, it is stated that "PCC tube gas temperature comparisons indicate that, for given inlet conditions, TRACG requires a somewhat greater length of the condenser tubes to achieve complete condensation." However, this point was not discussed in any individual test. Please explain how this conclusion is derived from the tests.

R141. This conclusion is reached by comparing the calculated and measured positions [[

]] The more important point is that both the test and the calculation show that the PCCS has significant margin relative to the long-term decay heat load.

References

1. *PANDA Facility, Test Program and Data Base General Description (DTR Umbrella Report)*, Alpha-606-0, PSI, May 1996 (Non-Proprietary).
2. *ESBWR Test Report,* NEDC-33081P, August 2002 (Section 2.2).
3. *ESBWR Scaling Report,* NEDC-33082P, Rev 0, December 2002 (Section 5.5).
4. Ibid. (Section 8).
5. Ibid. (Appendix A).
6. *TRACG Qualification for SBWR*, NEDC-32725P, V. 1, Rev. 1, August 2002 (Section 4.1).
7. Ibid. (Section 4.3)
8. *TRACG Qualification for ESBWR*, NEDC-33080P, August 2002.
9. *TRACG Application for ESBWR*, NEDC-33083P, September, 2002 (Section 3.3.1.1.3).
10. Ibid. (Section 3.3.1.1.1).
11. Ibid. (Section 3.3.1.1.2).
12. *TRACG Qualification for SBWR*, NEDC-32725P, V. 1, Rev. 1, August 2002 (Appendix B).
13. *TRACG Application for ESBWR*, NEDC-33083P, September, 2002 (Figure 3.7-2).

Q142. In Section 2.6.2.3, it is stated that "a relatively large uncertainty in poolside heat transfer could be tolerated without adversely affecting the ability of TRACG to calculate the behavior of the PCCS in context of an overall systems model of the containment." Please discuss how this conclusion was determined, and provide specific data, if any, to support this conclusion.

R142. The basis for this statement is that the poolside thermal resistance represents [[

]]

Section 2.6 Summary and Conclusions

Q143. In Section 2.6.2.8, it is stated that, "The modeling features described above have minimal impact on the calculation of system pressure and lead to a conservative prediction of WW gas temperature. The WW pressure is primarily set by the inventory of noncondensible gas with a minor contribution from the partial pressure of the steam in the gas space. The steam partial pressure is, in turn, set by the temperature at the surface of the SP [suppression pool]."

R143. Please see the responses to the individual questions below.

Q143.1. Please explain why the modeling leads to a conservative prediction of WW gas temperature.

R143.1. The modeling features cited [[

]]

Q143.2. In the long term, the containment pressure is determined by the partial pressure of the steam in the gas space in addition to the non-condensible gas mass in the WW gas space, which is determined by the liquid surface temperature, which is determined by how much of the uncondensed steam in the PCCS is deposited in the WW water. How well the PCCS performs eventually affects the WW liquid temperature and WW pressure. Please discuss why the partial pressure of the steam in the gas space is a minor contributor to the WW pressure. Please note that WW4 is ranked as high in the phenomena identification and ranking table (PIRT) for ESBWR Containment/LOCA.

R143.2. The word "minor" was in reference to the relative contributions of the noncondensable and the steam. [[

]]

Q213. Page 3-23, Section 3.3.7.3 - The statement is made that "The vacuum breakers have been redesigned to preclude failure to close." What was the problem with the earlier design? Does this refer to insufficient valve stroke to meet minimum flow requirements (page A-41, A.3.2.4.3)?

R213. Historically, BWRs have used swing check valves to provide wetwell to drywell vacuum breaking. Swing check valves have a pivot pin that rotates with the disk. Gravity acts to close the valve but the closure force is reduced as the valve closes. Despite the proven attributes of swing check valves, the ESBWR design team determined that a specially designed vacuum breaker valve would be desirable to meet the more stringent leak tightness and reliability criteria for passive check valves in the ESBWR.

The vacuum breaker redesign was not prompted by a valve stroke issue, rather during flow testing of the new valve it was determined that the valve stroke needed to be lengthened to achieve the minimum flow requirements.

Q214. Page 3-23, Section 3.3.7.3 - The statement is made that "A separate isolation valve can be activated in the vacuum breaker." How will the operator decide to do this? How will the operator know which vacuum breaker is leaking?

R214. Each vacuum breaker is instrumented with four proximity sensors located around the disk periphery. Alarms are provided to the operator for each vacuum breaker which indicate: (1) vacuum breaker leaking (2) vacuum breaker open, or (3) vacuum breaker sensor failure. The operator can then manually initiate isolation valve closure as necessary.

Q234. Page A-91, Figure A.3-1 - (1) Is the center vertical pipe (supplying steam to condenser tubes) insulated from the PCC pool water in the ESBWR design? Will there be any steam condensation inside the center vertical pipe during PCC operation? (2) Was the center vertical pipe insulated from the PCC pool water in the PANTHERS/PCC tests?

R234. The center riser pipe is not insulated from the PCC pool water in the ESBWR design and steam condensation is expected in this pipe during PCC operation. The center riser pipe was not insulated from the PCC pool water during the PANTHERS tests.

Q236. Page A-96 - Figure A.3-6 shows an IC unit. (1) Is the center vertical pipe (supplying steam to condenser tubes) insulated from the IC pool water in the ESBWR design? Will there be any steam condensation inside the center vertical pipe during IC operation? (2) Was the center vertical pipe insulated from the IC pool water in the PANTHERS/IC tests?

R236. The center vertical riser pipe of the IC in the ESBWR design is insulated from the IC pool water. Very little steam is expected to condense on the riser pipe during IC operation since the inner pipe wall will be close to actual steam temperature. The PANTHERS/IC test used an IC with a steam riser pipe that was insulated from the IC pool water.

Q257. Section 3.1 - The reader is referred to Figure 3.2-1. There is no such figure in this report.

R257. The Figure number should be 3-1 rather than 3.2-1. The change will be incorporated into the next revision of the report.

Q258. Equation 3.1-7 is incorrect. The dimensions of the second term of the right hand side do not match those of the other terms.

R258. There is a "+" missing between the second and third terms on the right hand side of equation 3.1-7.

The term $v\sum_k \dot{Q}_k$ should be $v + \sum_k \dot{Q}_k$. The change will be incorporated into the next revision of the report.

Q266. The second paragraph on page 4-5 states that the flow mass flux due to phase change at the surface of a pool "may depend of the fluid conditions on both sides of the interface." Under what circumstances is the mass flux independent of the fluid conditions?

R266. The words "may depend of" should be replaced with "depends on" The change will be incorporated into the next revision of the report.

Q275. Page 5-2, first sentence - Does it mean the tests or should it say the test facilities?

R275. The sentence should read "test facilities." The change will be incorporated into the next revision of the report.

Q276. The last sentence on the top paragraph of page 5-2 is not clear and should be revised.

R276. The word "area" in this sentence should be "are". The change will be incorporated into the next revision of the report.

Q279. Page 5-5, second paragraph - Reference is made to section 3.5. This section does not exist in this report.

R279. This section was deleted from the final version of the report. The reference should be to the ESBWR Design Description, NEDC-33084P, submitted in August 2002. The change will be incorporated into the next revision of the report.

Q281. Equation 6.1-3 is incorrect. The last term on the right hand side is inconsistent with the formulation provided in NEDC-32288P, "SBWR Scaling Report," page B-12, Equation (B.2-22).

R281. The "+" sign before the last summation sign on the right hand side of equation 6.1-3 should not be there. The change will be incorporated into the next revision of the report.