GE Nuclear Energy

Sandra A. Delvin
Manager, ESBWR
Engineering & Technology

General Electric Company
175 Curtner Avenue, M/C 307 San Jose, CA 95125-1014
408 925-3900 (phone) 408 925-5490 (facsimile)

Project 717

MFN 03-115
October 13, 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 (117.2, 306, 314.1, 322, 323.4, 329, and 406) for ESBWR Pre-application Review - Supplementary Information**

In response to a request from the NRC, GE Nuclear Energy is submitting, in enclosures 1 and 2, supplementary information in support of our response to Requests for Additional Information (RAI) number 117.2, 306, 314.1, 322, 323.4, 329, and 406, which were originally provided in the referenced letters.

Enclosure 1 contains the supplementary information with GE 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 information 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.

D068

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

Sincerely,

TRM

Sandra A. Delvin
Manager, ESBWR
Engineering & Technology

References:

1. MFN 03-057, Letter From Atam S. Rao (GE) to NRC, July 31, 2003, 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
2. MFN 03-070, Letter From Atam S. Rao (GE) to NRC, August 18, 2003, SUBJECT: RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION (RAI) NUMBERS (13, 14, 28-30, 33, 34, 36-44, 46, 49-53, 55, 57-59, 61-64, 66, 68, 69, 72-76, 78, 80, 81, 83-85, 88, 93, 96, 98, 99, 102-104, 107, 108, 110-112, 147-150, 153-158, 163, 165, 166, 168-175, 178-182, 185, 186, 188, 189, 192-194, 196-201, 203-212, 215-219, 221-224, 226-230, 233, 235, 237-256, 263, 265, 267-270, 273, 274, 278, 280, 283-285, 287-289, 291, 300, 302, 303, 318, 320, 322, 328, 332, 340-344, 348, 361, 362, 364-370, 377, 386, 407, 409-413) FOR ESBWR PRE-APPLICATION REVIEW
3. MFN 03-078, Letter From Sandra A. Delvin (GE) to NRC, August 20, 2003, SUBJECT: RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION (RAI) NUMBERS (1-5, 10-12, 25-27, 31, 32, 144-146, 151, 152, 160, 167, 177, 262, 277, 290, 294, 308, 312-315, 346, 360, 363, 380, 381, 383-385, and 389-405) FOR ESBWR PRE-APPLICATION REVIEW
4. MFN 03-079, Letter From Atam S. Rao (GE) to NRC, August 22, 2003, SUBJECT: RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION (RAI) NUMBERS (161, 162, 164, 176, 183, 184, 286, 292, 293, 295, 301, 323, 325, 339, and 382) FOR ESBWR PRE-APPLICATION REVIEW
5. MFN 03-083, Letter From Atam S. Rao (GE) to NRC, September 5, 2003, 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 ESBWSR PRE-APPLICATION REVIEW
6. MFN 03-104, Letter From Sandra A. Delvin (GE) to NRC, September 24, 2003, SUBJECT: RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION (RAI) NUMBERS (306 AND 339) FOR ESBWR PRE-APPLICATION REVIEW

Enclosures:

1. MFN 03-115 Response to NRC RAI number (117.2, 306, 314.1, 322, 323.4, 329, and 406) – Supplementary Information - Proprietary Information
2. MFN 03-115 Response to NRC RAI numbers (117.2, 306, 314.1, 322, 323.4, 329, and 406) – Supplementary Information - Non-proprietary Information – to be transmitted separately
3. Affidavit, George B. Stramback, dated October 13, 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 03-115, Sandra A. Delvin to NRC, *Response to Request for Additional Information (RAI) number (117.2, 306, 314.1, 322, 323.4, 329, and 406) for ESBWR Pre-application Review – Supplementary Information,* dated October 13, 2003. The proprietary information is in Enclosure 1, *Response to NRC RAI number (117.2, 306, 314.1, 322, 323.4, 329, and 406) – Supplementary Information.* 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 13th day of October 2003.

George B. Stramback
General Electric Company

ENCLOSURE 2

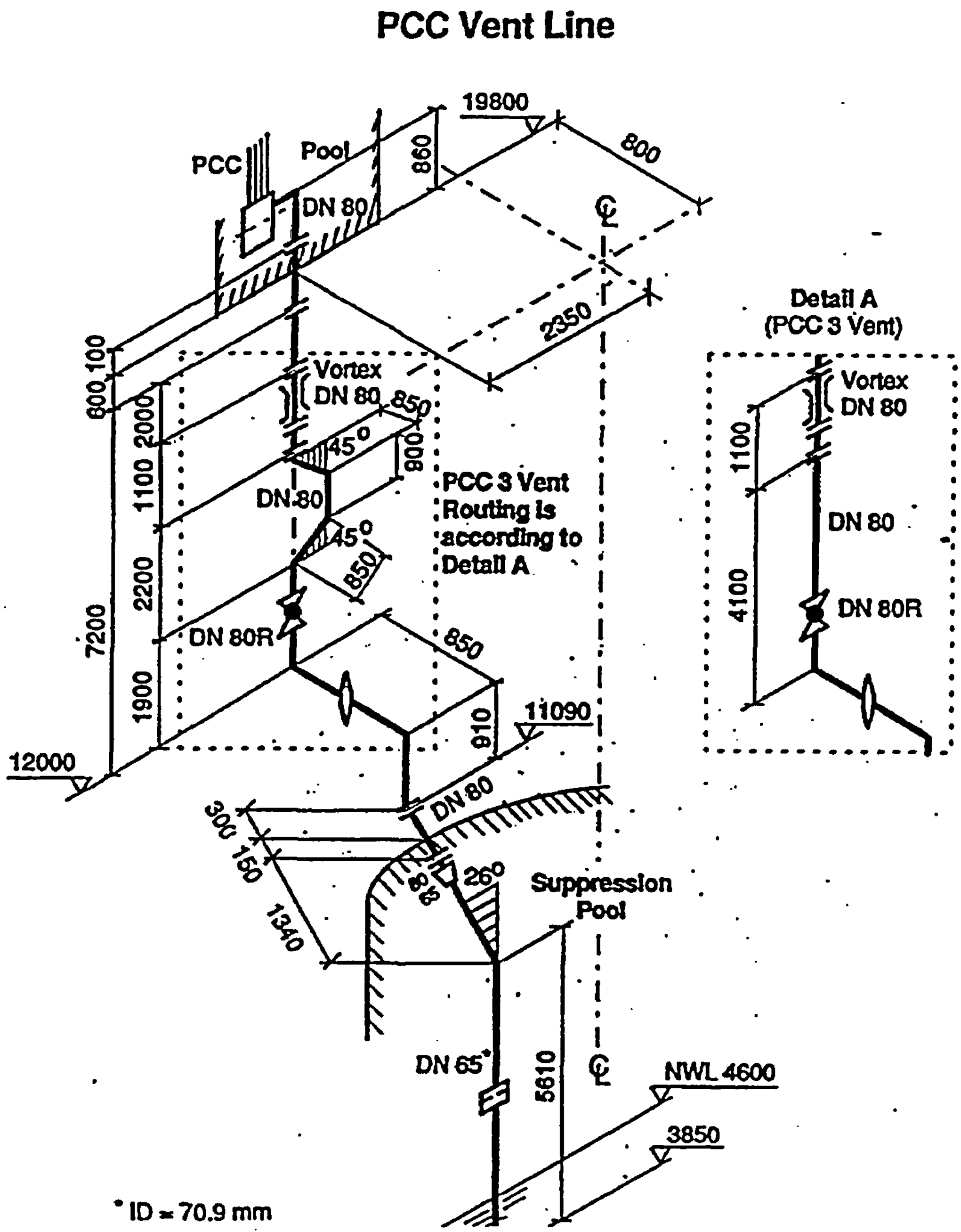
MFN 03-115

Response to NRC RAI numbers (117.2, 306, 314.1, 322, 323.4, 329, and 406) – Supplementary Information

Supplementary Information for RAI 117.2

Supplementary Information for RAI 117.2

PCC Vent Pressure Tap – Located on downstream side of vortex flow meter



Supplementary Information in Response to RAI 306

The correlation used for interfacial heat transfer at a horizontal 'level' (e.g. surface of the suppression pool) in TRACG is attributed to Holman. This correlation is given in metric units as

$$h = 1.43\ (\Delta T)^{1/3} \tag{1}$$

It was generalized in TRACG by explicitly accounting for the conductivity of the fluid, as:

$$h = 45.04\ k(\Delta T)^{1/3} \tag{2}$$

This correlation is strictly applicable only to the case of turbulent flow over a solid horizontal plate with the hot side facing up.

In TRACG, this equation is applied to both sides of the interface (liquid to interface and vapor to interface). So the temperature condition of a hot horizontal plate facing up (or cold plate facing down) will not be met for both sides. For the situation of turbulent flow over a hot horizontal plate facing down, an alternate correlation is available as:

$$h = 0.12\ (\Delta T/L)^{1/4} \text{ (British units)} \tag{3}$$

$$h = 0.59\ (\Delta T/L)^{1/4} \text{ (Metric units)} \tag{4}$$

For $L = 2$ m and $\Delta T = 100$K, Equation 1 gives a heat transfer coefficient of 6.6 W/(m^{2}K); Equation 4 gives a value of 1.57 W/(m^{2}K).

[[

]]

Reference:

[306-1]W. H. McAdams, Heat Transmission, Third Edition, McGraw-Hill, New York, 1954, pages 172 and 180.

Supplemental Information for RAI 314.1

Question:
PCCS Performance During Blowdown

In response to RAI 314.1, it was stated that the PCCS removes about 15% of the blowdown energy. In response to RAIs 335 and 340, it was stated that the PCCS vent submergence is deep enough to avoid stratification but not so deep that it stops the vent function.

1. Provide a road map locating the source of data that demonstrates the PCCS performance (to condensing steam) during the blowdown portion of the event. Under these conditions (flow rates, steam and noncondensible fractions) will the PCCS condense 100% of the steam?

2. If the PCCS cannot condense 100% of the steam, provide a road map locating the source of the data that demonstrates that the PCCS vent submergence is low enough to condense the steam in the suppression pool, such that only noncondensible gases enter the wetwell.

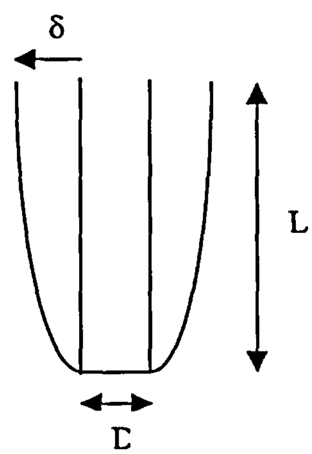
Response:

1 The attached Figure 1 shows the flow rates through the PCCS calculated by TRACG for the first 2000 seconds of the transient. The flow is for 3 PCC units lumped into one in the TRACG model. Hence the flow per PCC is the flow shown in the figure divided by 3. Most of the flow in this phase flows through the main vents. The PCC flow varies from approximately [[ ]]. Figure 2 shows the noncondensible partial pressure at the PCC inlet during the same time period. After clearing out the noncondensibles above the steam line break location in the first couple of seconds, the flow is essentially all steam until 10 minutes into the transient.
The flow rate of [[ ]] is within the test database of the PANTHERS tests. At PANTHERS, a full SBWR-scale PCC unit was tested over a steam flow range between [[ ]]. Steam-air tests were also conducted over the same steam flow range combined with an air flow range of [[ ]] (Table A.3-2 of ESBWR TAPD, NEDC-33079P). The ESBWR PCC has similar dimensions but has [[ ]] tubes.
The steam only tests were conducted allowing the PCC pressure to adjust such that all the incoming steam was condensed. Figure 4.1-14 in NEDC-32725P, TRACG Qualification for SBWR, Vol. 1, shows that TRACG calculated the required pressure to condense the steam flow conservatively. (The data point on the right side of the figure corresponds to a steam flow rate of [[ ]]). Figure 1 also shows that a part of the steam flowing through the PCCs is not condensed . The uncondensed steam flow drops from [[ ]] to a small value at 300s. Beyond this time, a combination of increase

in PCC pressure and reducing steam flow through the PCCs allows the PCC condensing capacity to catch up with steam flow.

The most relevant data for condensation efficiency of steam discharged through the PCC vent can be found in Reference 1. In the LINX test facility, tests were performed with a vent pipe with an I.D. of 40 mm and submergences ranging from 37.5 to 75 cm. Steam flow rates ranged up to 50 g/s. This mass flux corresponds to a flow rate of [[ ]] in an ESBWR-size vent of [[ ]]. The test data showed that the steam was fully condensed in all the tests, with even low submergences until the pool temperature got to a few degrees below saturation. At typical subcoolings, the steam was condensed at a distance of 10 to 15 cm (L/D = 3 to 4) above the vent discharge. A simple argument can be made that condensation will be complete for a pipe of a different size at the same L/D or less when the mass flux is the same. Assuming equal L/D, the required submergence is of the order of [[ ]].

> [Justification: For a discharge steam flow rate W, assume an interfacial area A_i is needed for complete condensation. The steam flows upward a distance L as a growing thermal plume around the vent pipe of diameter D until it is condensed. The required interfacial area is proportional to the plume volume.



For a given subcooling,
$W = k_1 A_i = k\pi D\delta L$
$W/\pi D^2 = k\delta L/D$
δ varies as $L^{1/2}$ to L
Thus,
$W/\pi D^2 = KL^{1.5 \text{ to } 2}/D$
For the same mass flux, the condensation length L will vary as the diameter to the ½ to 2/3 power.]

In the time frame of interest, the main vents are also open. The mixing in the suppression pool will be far greater than that for a PCC vent discharging into a quiescent pool. This will help condensation of the steam even more efficiently.

Reference 1: C. De Walsche, F. de Cachard, "Experimental Invetigation of Condensation and Mixing during Venting of Steam/Non-Condensable Gas Mixture into a Pressure Suppression Pool", ICONE-8565, Proceedings of ICONE 8, 8th International Conference on Nuclear Engineering, April 2-6, 2000, Baltimore, MD, USA

[[

]]

Figure 1: TRACG plot: 3 PCC inlet and vent flow for 2000 sec

[[

]]

Figure 2: TRACG plot: 3 PCC inlet total and air partial pressure for 2000 sec

Supplemental Information to RAI 322

Q322 NEDC-33083P, Section 2.2.1.2 defines the Main Steam Line Break (MSLB) LOCA scenario. It assumes that the feedwater flow is not available during the transient. From the emergency core cooling system (ECCS) LOCA evaluation perspective, this assumption leads to conservative ECCS performance evaluation. For containment analysis, it is the common practice to assume that the feedwater flow is available during the LOCA and the injection continues until all the hot water from the feedwater system is consumed. Please provide justification and explain why the feedwater flow is assumed to be cut off during MSLB and why it is conservative to do so.

R322. For the MSLB containment response analysis, the SAR calculation will assume an appropriate feedwater flow (based on the final design of the feedwater system), consistent with past practice. The calculation performed in NEDC-33083P assumed a simplified feedwater flow coast down in the analysis. It is expected that the assumption of the feedwater flow coast down will have a very limited impact on the ESBWR MSLB response because the peak containment pressure for this break is determined primarily by the wetwell volume and GDCS pool partial drain down. Since any reasonable addition of feedwater flow will not impact the wetwell airspace and GDCS drain down volume, any impact on the containment pressure is expected to be minimal. The impact of any added energy with the feedwater system is also different (compared to standard BWRs) for the ESBWR as the design has a PCCS system, which would remove any additional energy without significantly heating up the suppression pool.

Supplement to RAI 322 Response

A sensitivity study was performed to assess the impact of all available hot water from the ESBWR feedwater system on the containment pressure during a LOCA. The Baseline Main Steam Line Break (MSLB) was used in this study. In a sensitivity case, feedwater flow is assumed to be available until all the hot water from the feedwater system is consumed. The results of this study show that the impact on peak drywell pressure is
[[ ]]

Supplemental Information for RAI 323.4

TRACG uses realistic models to calculate the effects of compression of the noncondensibles and heat transfer to the walls on the wetwell gas temperature. A sensitivity study was performed to assess the impact of using a lower bound value for the wetwell gas temperature on the two-phase water level in the RPV chimney. The result shows that the maximum impact is an [[ ]] delay in the starting time of the GDCS flow, and a reduction of [[ ]] in the minimum static head in the chimney.

TRACG calculates a peak wetwell gas temperature of [[ ]] at about [[ ]], or a short time before the initiation of GDCS flow in the ECCS/LOCA Base case (GDCS line break). This WW gas temperature is reasonable when compared to the lower bound value of [[ ]] (TRACG calculated suppression pool surface temperature) and the upper bound value of [[ ]] (calculated by isentropic compression, assuming all noncondensible gases in the WW airspace). A lower WW gas temperature would have the effect of reducing the WW gas pressure, which in turn, decreases the GDCS driving head and delays the starting time of the GDCS flow. The estimated delay time based on the RPV depressurization response and perfect gas assumption in the wetwell gas space is [[ ]] if the WW gas temperature is set equal to the lower bound value of [[ ]]. A TRACG parametric case was performed with [[ ]] delay on the initiation time of the GDCS flow. The effect was to reduce the minimum static head in the chimney by [[ ]].

Supplemental Information for RAI 329

Additional parametric 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 1.4791. The other radial peaking factors were 1.00 for the 492 bundles feeding the chimney region in Ring 2 and 0.7263 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 additional 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.

Supplemental Information for RAI 406

Additional parametric cases were analyzed to determine the duration of the hot channel high void flow and minimum thermal margin. There are the GDCS Line LOCA, Main Steam Line LOCA and Bottom Drain Line LOCA cases. These cases were 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 discussed in RAI 329. In these cases, the radial peaking factor for all the bundles feeding the chimney region in Ring 1 was set equal to 1.4791.

No core heatup was calculated for all these cases. The hot channel peak void fraction and minimum thermal margin during the transient for these cases are summarized in the following table. Significant margin to boiling transition (> 2) is calculated during the high void period of depressurization.

[[

]]