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Proprietary Notice
This letter forwards proprietary information in accordance with 10CFR2.390. Upon the removal of Enclosure 1, the balance of this letter may be considered non-proprietary.

MFN 07-013

Docket No. 52-010

January 10, 2007

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

Subject: **Response to Portion of NRC Request for Additional Information Letter No. 43 Related to ESBWR Design Certification Application - ESBWR Probabilistic Risk Assessment - RAI Numbers 19.1-11, 19.1-12, 19.1-19, 19.2-7, 19.2-25, 19.2-32, and 19.2-36**

Enclosure 1 contains proprietary information as defined in 10CFR2.390. 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 proprietary information in Enclosure 1 be withheld from public disclosure in accordance with the provisions of 10 CFR 2.390 and 9.17. A non proprietary version is contained in Enclosure 2.

If you have any questions or require additional information regarding the information provided here, please contact me.

Sincerely,

Kathy Sedney for

James C. Kinsey
Project Manager, ESBWR Licensing

D068

Reference:

1. MFN 06-222, Letter from U.S. Nuclear Regulatory Commission to David Hinds, *Request for Additional Information Letter No. 43 for the ESBWR Design Certification Application*, July 5, 2006

Enclosures:

1. MFN 07-013, Response to Portion of NRC Request for Additional Information Letter No. 40 Related to ESBWR Design Certification Application - ESBWR Probabilistic Risk Assessment - RAI Numbers 19.1-11, 19.1-12, 19.1-19, 19.2-7, 19.2-25, 19.2-32, and 19.2-36 – GE Proprietary Information
2. MFN 07-013, Response to Portion of NRC Request for Additional Information Letter No. 40 Related to ESBWR Design Certification Application - ESBWR Probabilistic Risk Assessment - RAI Numbers 19.1-11, 19.1-12, 19.1-19, 19.2-7, 19.2-25, 19.2-32, and 19.2-36 – Non Proprietary Version
3. Affidavit – David Hinds – dated January 10, 2007

cc: AE Cubbage USNRC (with enclosures)
David Hinds GE/Wilmington (with enclosures)
eDRF 0000-0060-3203
0000-0060-3207
0000-0060-5636
0000-0060-5625

Enclosure 2

MFN 07-013

Response to Portion of NRC Request for

Additional Information Letter No. 40

Related to ESBWR Design Certification Application

ESBWR Probabilistic Risk Assessment

RAI Numbers 19.1-11, 19.1-12, 19.1-19, 19.2-7, 19.2-25, 19.2-32, and 19.2-36

Non-Proprietary Version

NRC RAI 19.1-11

Section 8 outlines the details behind CSETs, Accident Classes, Containment Phenomenological Event Trees (CPETs), and the Source Term Release Category Grouping. However, the sequence binning process and the algorithm used to integrate these steps is not described. Thus, it is not possible to trace an accident sequence from its inception (accident initiation in Level 1 Probabilistic Risk Assessment (PRA)) to its final outcome (source terms in Level 2/3 PRA). In this regard, provide a description of the process and algorithms used to integrate the above mentioned steps. Include a discussion of how the sequences used to generate the source terms are representative of their respective Release Categories.

GE Response

Sections 8 and 21 of NEDO 33201, Rev. 1 explain the structure of the Containment Systems Event Trees (CSETs) and Containment Phenomenological Event Trees (CPETs). Appendix A.8 to Section 8 describes the quantification of the containment event trees, bringing together the CPETs and CSETs, and linking them to the Level 1 PRA results.

Appendix A.8 describes the sequence binning process and the information supporting the node probabilities of the CPETs and CSETs. The results of the containment event tree quantification are also presented in this appendix, for each sequence in the event-tree figures, and summarized in Table A.8-3. The association of the frequencies with the source terms for each release category is presented in Section 9.

Table A.8-1 of Appendix A.8 presents the binning of the Level 1 accident sequences into Level 2 subclasses. Table A.8-1 is reproduced in this RAI response as Table 1, with additional information included, in an attempt to clarify how the Level 2 subclasses were defined and how their frequencies were calculated. Only the Level 1 accident sequences resulting in CDFs above the truncation limit were carried over to the Level 2 PRA, and included in Tables A.8-1 and 1.

The first three columns of Table 1 present the Level 1 accident sequences, the initiating events for each sequence, and corresponding CDFs. The accident sequences are grouped by the core damage class assigned to them in the Level 1 PRA (Sequences 8 and 9 of Table 1 were categorized as Class III in the Level 1 PRA, but are in reality low pressure sequences, and are therefore, grouped with the other Class I sequences). For the reasons described in Section A.8.1, these classes had to be split into subclasses for the Level 2 model. Column "L2 Subclass" shows these subclasses and the sequences binned into them, while the following column shows the corresponding CDFs. The L2 Subclass CDFs are the sums of the CDFs of the sequences binned into each subclass.

The subclass CDFs are the initiating event frequencies for the containment event trees shown in Figures A.8-1 through A.8-6. Each one of these figures shows a CPET at the top, with the initiating event frequency from Table 1, followed by a CSET underneath it. The initiating event frequency of the CSET is the sum of the sequence frequencies labeled as "Transfer" in the CPET.

The node probabilities of the containment event trees are shown on each branch, and are summarized in Table A.8-2. A justification for these probabilities is presented in Section A.8.2.

Table 1 provides additional clarification on the calculation of split fractions for node LD_LVL, described in A.8.2.6. The last 3 columns of Table 1 show the binning of the subclasses into low-water-level and high-water-level bins (described in A.8.1), the CDF corresponding to each bin, and the corresponding bin ratio. Bin ratios are required only for L2 Subclasses IN and IVN. They are calculated by dividing the bin CDF by the subclass CDF. Based on the explanation in A.8.2.6, a split fraction of 2.30E-3 is assigned to the medium water level branch (LD_L2) of node LD_LVL. The split fraction for the low water level branch (LD_L1) is obtained by subtracting 2.30E-3 from the "Low (+Medium)" bin ratio in Table 1. The "High" bin ratio in Table 1 represents the split fraction for the high water level branch (LD_L3) of node LD_LVL.

The dependence between the Level 1 and Level 2 models is taken into account by calculating specific conditional probabilities for the Level 2 nodes that are dependent on the input Level 1 sequences, as described in Section A.8.2.

In summary, to trace an accident sequence from its inception to its final outcome, one can find the Level 1 PRA initiating event in Table A.8-1 (or Table 1 of this RAI response), determine which accident sequences belong to a certain Level 2 subclass, then follow the accident progression in the CPET with the initiating event labeled with the L2 subclass name (in one of the Figures A.8-1 through A.8-6). Some CPET sequences lead to a release category; others transfer to the CSET at the bottom of the page leading to additional release categories. The frequencies corresponding to the containment event tree sequences are shown in the figures, and summarized in Table A.8-3.

A discussion of how the sequences used to generate the source terms are representative of their respective release categories is presented in Section 9 of NEDO 33201, Rev. 1. Tables 9-1, 9-2, and 9-3 provide the releases associated with the end states of the containment event trees, as well as the representative MAAP sequences used to calculate these releases.

Table 9-1 summarizes the ESBWR release categories and associated frequencies. As indicated in Table 9-1, the release category "TSL", which depicts an intact containment with only leakage providing a source term, is the most likely release category. Other release categories have much lower calculated frequencies. For conservatism, a truncation frequency was used to represent some of these release categories. Specifically, if the calculated probability of the category was less than 10^{-12}, the truncation value of 10^{-12} was carried forward for the consequence evaluation. Table 9-1 includes the representative MAAP sequences as well as the time of initial release, and cumulative release fractions of noble gas and CsI at 24 and 72 hours after onset of core damage. Tables 9-2 and 9-3 provide the radionuclide release spectrum for 24 and 72 hours after onset of core damage, respectively.

DCD Impact

No DCD changes will be made in response to this RAI.

Table 1: Mapping of Level 1 Sequences to Level 2 Subclasses, and LDW Water Level Bins (Based on Table A.8-1)

<table>
<tr><th>No</th><th>Sequence</th><th>Initiating Event</th><th>CDF</th><th>Level 1 Class</th><th>L2 Subclass</th><th>L2 Sub-class CDF</th><th>LDW Water Level Bin</th><th>Water Level Bin CDF</th><th>Bin Ratio</th></tr>
<tr><td>1</td><td>T-LOPP044</td><td>T-LOPP</td><td>1.63E-08</td><td rowspan="8">CDI</td><td rowspan="2">IL</td><td rowspan="2">1.63E-08</td><td rowspan="2">Low</td><td rowspan="2" colspan="2">N/A</td></tr>
<tr><td>2</td><td>AT-T-LOPP011</td><td>AT-T-LOPP</td><td>5.66E-12</td></tr>
<tr><td>3</td><td>T-FDW044</td><td>T-FDW</td><td>1.20E-08</td><td rowspan="16">IN</td><td rowspan="16">1.24E-08</td><td rowspan="8">Low (+Medium)*</td><td rowspan="8">1.21E-08</td><td rowspan="8">9.80E-01</td></tr>
<tr><td>4</td><td>T-IORV014</td><td>T-IORV</td><td>2.13E-11</td></tr>
<tr><td>5</td><td>T-IORV028</td><td>T-IORV</td><td>1.15E-11</td></tr>
<tr><td>6</td><td>AT-T-FDW011</td><td>AT-T-FDW</td><td>4.94E-12</td></tr>
<tr><td>7</td><td>AT-T-SW003</td><td>AT-T-SW</td><td>5.70E-13</td></tr>
<tr><td>8</td><td>LL-S-014</td><td>LL-S</td><td>2.16E-13</td></tr>
<tr><td>9</td><td>T-IORV015</td><td>T-IORV</td><td>1.07E-11</td><td rowspan="2">CDIII</td></tr>
<tr><td>10</td><td>T-IORV029</td><td>T-IORV</td><td>7.13E-11</td></tr>
<tr><td>11</td><td>ML-L-014</td><td>ML-L</td><td>2.23E-10</td><td rowspan="8">CDI</td><td rowspan="8">High</td><td rowspan="8">2.50E-10</td><td rowspan="8">2.02E-02</td></tr>
<tr><td>12</td><td>LL-S-FDWB013</td><td>LL-S-FDWB</td><td>2.36E-11</td></tr>
<tr><td>13</td><td>ML-L-RWCU013</td><td>ML-L-RWCU</td><td>1.27E-12</td></tr>
<tr><td>14</td><td>LL-S-FDWA013</td><td>LL-S-FDWA</td><td>1.03E-12</td></tr>
<tr><td>15</td><td>SL-L-RWCU014</td><td>SL-L-RWCU</td><td>8.07E-13</td></tr>
<tr><td>16</td><td>SL-L-015</td><td>SL-L</td><td>4.39E-13</td></tr>
<tr><td>17</td><td>SL-L-RWCU027</td><td>SL-L-RWCU</td><td>2.64E-13</td></tr>
<tr><td>18</td><td>SL-L-029</td><td>SL-L</td><td>1.06E-13</td></tr>
<tr><td>19</td><td>T-LOPP049</td><td>T-LOPP</td><td>3.19E-10</td><td rowspan="9">CDIII</td><td rowspan="2">IIIL</td><td rowspan="2">3.20E-10</td><td rowspan="9">N/A</td><td rowspan="9" colspan="2">N/A</td></tr>
<tr><td>20</td><td>T-LOPP030</td><td>T-LOPP</td><td>8.72E-13</td></tr>
<tr><td>21</td><td>T-GEN031</td><td>T-GEN</td><td>4.64E-12</td><td rowspan="7">IIIN</td><td rowspan="7">9.01E-12</td></tr>
<tr><td>22</td><td>T-PCSB030</td><td>T-PCSB</td><td>2.07E-12</td></tr>
<tr><td>23</td><td>T-PCS030</td><td>T-PCS</td><td>1.30E-12</td></tr>
<tr><td>24</td><td>SL-S-029</td><td>SL-S</td><td>5.31E-13</td></tr>
<tr><td>25</td><td>T-FDW049</td><td>T-FDW</td><td>2.26E-13</td></tr>
<tr><td>26</td><td>ML-L-015</td><td>ML-L</td><td>1.21E-13</td></tr>
<tr><td>27</td><td>SL-L-RWCU028</td><td>SL-L-RWCU</td><td>1.11E-13</td></tr>
</table>

Table 1: Mapping of Level 1 Sequences to Level 2 Subclasses, and LDW Water Level Bins (Based on Table A.8-1)
(Continued)

<table>
<tr><th>No</th><th>Sequence</th><th>Initiating Event</th><th>CDF</th><th>Level 1 Class</th><th>L2 Subclass</th><th>L2 Sub-class CDF</th><th>LDW Water Level Bin</th><th>Water Level Bin CDF</th><th>Bin Ratio</th></tr>
<tr><td>28</td><td>AT-T-LOPP012</td><td>AT-T-LOPP</td><td>4.07E-12</td><td rowspan="14">CDIV</td><td rowspan="2">IVL</td><td rowspan="2">4.21E-12</td><td rowspan="2">Low</td><td rowspan="2" colspan="2">N/A</td></tr>
<tr><td>29</td><td>AT-T-LOPP013</td><td>AT-T-LOPP</td><td>1.37E-13</td></tr>
<tr><td>30</td><td>AT-T-GEN012</td><td>AT-T-GEN</td><td>1.19E-10</td><td rowspan="12">IVN</td><td rowspan="12">1.79E-10</td><td rowspan="10">Low(+Medium)*</td><td rowspan="10">1.77E-10</td><td rowspan="10">9.89E-01</td></tr>
<tr><td>31</td><td>AT-T-PCS012</td><td>AT-T-PCS</td><td>3.31E-11</td></tr>
<tr><td>32</td><td>AT-T-FDW012</td><td>AT-T-FDW</td><td>8.47E-12</td></tr>
<tr><td>33</td><td>AT-T-GEN013</td><td>AT-T-GEN</td><td>5.49E-12</td></tr>
<tr><td>34</td><td>AT-T-IORV006</td><td>AT-T-IORV</td><td>4.07E-12</td></tr>
<tr><td>35</td><td>LL-S-016</td><td>LL-S</td><td>3.33E-12</td></tr>
<tr><td>36</td><td>AT-T-PCS015</td><td>AT-T-PCS</td><td>1.41E-12</td></tr>
<tr><td>37</td><td>AT-T-PCS013</td><td>AT-T-PCS</td><td>1.11E-12</td></tr>
<tr><td>38</td><td>AT-T-FDW013</td><td>AT-T-FDW</td><td>2.75E-13</td></tr>
<tr><td>39</td><td>AT-T-IORV007</td><td>AT-T-IORV</td><td>1.37E-13</td></tr>
<tr><td>40</td><td>SL-L-RWCU029</td><td>SL-L-RWCU</td><td>1.71E-12</td><td rowspan="2">High</td><td rowspan="2">1.96E-12</td><td rowspan="2">1.10E-02</td></tr>
<tr><td>41</td><td>ML-L-017</td><td>ML-L</td><td>2.51E-13</td></tr>
<tr><td>42</td><td>BOC-FDWB046</td><td>BOC-FDWB</td><td>2.04E-12</td><td rowspan="5">CDV</td><td rowspan="5">V</td><td rowspan="5">4.27E-12</td><td rowspan="5">N/A</td><td rowspan="5" colspan="2">N/A</td></tr>
<tr><td>43</td><td>BOC-FDWB041</td><td>BOC-FDWB</td><td>9.79E-13</td></tr>
<tr><td>44</td><td>BOC-FDWB045</td><td>BOC-FDWB</td><td>5.29E-13</td></tr>
<tr><td>45</td><td>BOC-FDWB042</td><td>BOC-FDWB</td><td>4.90E-13</td></tr>
<tr><td>46</td><td>BOC-RWCU045</td><td>BOC-RWCU</td><td>2.33E-13</td></tr>
</table>

* The LDW Water Level Bin labeled "Low (+Medium)" indicates that the corresponding bin ratio includes both the "Low" and the "Medium" split fractions for Node LD_LVL of the CSETs, although, the sequences binned in this category lead only to low water level in the LDW. The explanation for this is documented in Section A.8.2.6 of NEDO 33201, Rev. 1.

NRC RAI 19.1-12

For sequence "MLI_nVB_nCHR" in the PRA, it is our understanding that the water in suppression pool is expected to flow to the lower drywell through the equalization line break, and flow back to the RPV through the other end of the line break when the water level inside the drywell reaches the elevation of the break, thus keeping the core cool. Elaborate on the sequences of events that are eventually expected to result in core damage, given this feature.

GE Response

This sequence was modeled in NEDO-33201, Revision 0 to provide insights for sequences grouped into Accident Class II. In Revision 1 NEDO-33201, sequence MLi_nCHR was selected to represent containment response to Class II events.

This sequence does begin with the core covered. However, without containment heat removal, the containment pressurizes to the ultimate capacity. Inventory is lost through the containment failure (expected failure location is the drywell head) eventually leading to core uncovery; 58 hours in MLi_nVB_nCHR and 71 hours in MLi_nCHR.

It is noted that similar sequences were evaluated in Chapter 11 of the ESBWR PRA, Uncertainty and Sensitivity Analysis. This sensitivity analysis, 72 hour mission time, included additional active systems to mitigate the similar sequences and resulted in lowering the core damage frequency to below the truncation value of 1E-13/yr.

DCD Impact

No DCD changes will be made in response to this RAI.

NRC RAI 19.1-19

Provide an assessment of the ESBWR Level 2 PRA against the High Level and Supporting Requirements of the large early release frequency (LERF) analysis in Section 4.5.9 of the American Society of Mechanical Engineers (ASME) PRA Standard, and a judgment regarding the capability categories of the model in key areas.

GE Response

The ESBWR Level 2 PRA is described in NEDO-33201 Revision 1 Chapter 8 (Containment Systems Performance), Chapter 9 (Source Term) and Chapter 21 (Severe Accident Management). The purpose of the ESBWR Level 2 PRA is to determine the "containment effectiveness" in a severe accident and to develop conservative source terms for use in the offsite consequence analysis presented in Chapter 10 (Consequence Analysis, Level 3 PRA). The containment effectiveness was compared to the conditional containment failure probability guideline in SECY-93-087, "Policy, Technical and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor (ALWR) Designs". In accordance with Draft Regulatory Guide DG-1145 – Combined License Applications for Nuclear Power Plants (LWR Edition), the ESBWR Level 2 PRA was performed to assess the plant design against the goal of less than 1E-6/yr for large release frequency and the large early release frequency was not calculated.

The High Level Requirements (HLR) for LERF Analysis in the ASME PRA Standard include the following:

A. Core damage sequences shall be grouped into plant damage states based on their accident progression attributes.

   - The ESBWR core damage sequences are grouped into subclasses based on accident class and availability of offsite power. Due to the passive nature of the ESBWR, there are a limited number of mitigating systems considered in the evaluation of containment response and only a limited number of Level 1 bins are required to perform the Level 2 analysis.
   - The ESBWR Level 2 analysis is consistent with the supporting requirements (SR) for this HLR.
   - These SRs are not different for the capability categories for this HLR.

B. The accident progression analyses shall include an evaluation of contributors (e.g., phenomena, equipment failures, and human actions) to a large early release.

   - The accident progression analyses include required contributors to determine release timing and magnitude. The accident progression analyses consist of containment phenomenological event trees (CPET) and containment systems event trees (CSET).
   - The SRs for this HLR reference a table of LERF contributors to be considered. The ESBWR Level 2 analysis includes an evaluation of the applicable contributors.
   - A capability category of II is met for this HLR.

C. The accident progression analysis shall include identification of those sequences that would result in a large early release.

- The accident progression analysis identifies sequences based on release timing and magnitude. These sequences are binned for input into the Level 3 analysis.
- The SRs for this HLR describe inputs for a Level 2 accident sequence analysis. These inputs are generally considered in the ESBWR Level 2 analysis.
- A capability category of I is met for this HLR. A higher capability category was not met for this HLR due to the lack of applicable EOPs/SAMGs and resulting operator actions.

D. The accident progression analysis shall include an evaluation of the containment structural capability for those containment challenges that would result in a large early release.

- The Level 2 analysis includes an estimate of the containment ultimate strength. This analysis includes a finite element model for the reinforced concrete containment vessel, structural capability of the drywell head under internal pressure and temperature loading, PCCS heat exchangers ultimate pressure capability and leakage potential of the containment liner plate and penetrations.
- The SRs for this HLR describe factors for consideration when evaluating the containment structural capability. The applicable factors are considered in the ESBWR Level 2 analysis.
- A capability category of I is met for this HLR. Due to the screening nature of the containment isolation analysis, a higher capability category was not met for this HLR.

E. The frequency of different containment failure modes leading to a large early release shall be quantified and aggregated.

- The containment response to a severe accident is depicted by the end states of containment event trees. These end states become the "release categories" that are used to characterize potential source terms. These end states also depict containment failure modes.
- The SRs for this HLR describe requirements for the quantification of LERF sequences. The ESBWR Level 2 analysis does not quantify LERF, however, these requirements are generally met. The calculated release frequencies are used as input into the ESBWR Level 3 analysis.
- A capability category of I is met for this HLR due to the conservative nature of the ESBWR Level 2 analysis.

F. The quantification results shall be reviewed and significant contributors to LERF, such as plant damage states, containment challenges and failure modes, shall be identified. Key sources of uncertainty shall be identified and their impact characterized.

- Since LERF is not calculated, significant contributors to LERF are not identified. Key sources of uncertainty are identified in the analysis and conservative values are chosen to reflect these inputs.
- The SRs for this HLR describe a method to review the results for contributors to LERF and key sources of uncertainty. The ESBWR Level 2 analysis identifies sources of uncertainty and treats them in a bounding manner.
- A capability category of I is met for this HLR. Significant contributors to the release frequencies are illustrated but they are not identified or summarized.

G. The LERF analysis shall be documented consistent with the applicable supporting requirements.

- The accident progression analysis is documented to support certification of the ESBWR design. Other PRA applications and upgrades do not apply to this stage of the ESBWR design.
- The SRs for this HLR describe requirements for documentation of the LERF analysis. The ESBWR Level 2 analysis documents the process used and key assumptions and sources of uncertainty.
- A capability category of II is met for this HLR.

Revisions to the ESWBWR Level 2 analysis, which are planned and which will raise the capability category, include:

1) Incorporation of the EOPs/SAMGs and resulting operator actions.
2) A more detailed containment isolation analysis.

Significant contributors to large release frequency will be identified and summarized.

DCD/LTR Impact

No DCD changes will be made in response to this RAI. NEDO-33201 will be changed as described above in Revision 2.

NRC RAI 19.2-7

Provide an estimate of the maximum number of cycles that each vacuum breaker might be exposed to during a potential severe accident sequence, and the basis for this estimate. Justify the probability of vacuum breaker leakage or failure to open/close given this number of cycles.

GE Response

The results for the TRACG evaluations described in DCD Tier 2 Revision 2 Chapter 6, Sections 6.2.1.1.3.1, 6.2.1.1.3.2, 6.2.1.1.3.3, 6.2.1.1.3.4 and 6.2.1.1.3.5, show the vacuum breakers cycling from 3 to 23 times. The events analyzed included: Feedwater line break (Nominal Analysis), Main Steam Line Break (Nominal Analysis), GDCS Line Break and Bottom Drain Line Break (Nominal Analysis), Feedwater line break (Bounding Analysis), and Main Steam Line Break (Bounding Analysis). Therefore, it is estimated that the maximum number of cycles that each vacuum breaker would be exposed would be about 23.

As described in NEDO-33201 Rev 1, Section 5.2, the failure rate is calculated by updating the generic failure rate from NUREG/CR-2728 of 1.25E-5/d. The value for a generic test interval is updated to account for the vacuum breaker test interval. It is expected that the vacuum breakers will be tested each refuel cycle. Using the described method, the resulting failure rate is 1E-4/d.

The failure rate for additional cycles during an event, after the first cycle, would not be influenced by the test interval, 1 refuel cycle. Therefore, it would be expected the failure rate would be at or below the generic rate.

This failure rate is consistent with the results of the test conducted on the SBWR Vacuum Breaker in 1994. There were no failures observed in 3000 cycles of the prototype valve.

DCD Impact

No DCD changes will be made in response to this RAI.

NRC RAI 19.2-25

Provide additional information regarding the BiMAC cooling jacket arrangement in the vicinity of the two sumps in the lower drywell floor, which the BiMAC is designed to protect, and the wall/floor area adjacent to the downcomer/deluge lines and nearedge channels. Include an overlay of PRA Figures 21.5.2-1c and e, and an isometric drawing. Discuss how the BiMAC piping in these two areas was treated in the computational fluid dynamic (CFD) simulations. Discuss whether asymmetries in these areas and the protection of the wall/floor area adjacent to the downcomer/deluge lines by only a limited number of near-edge channels can introduce the potential for steam starvation and local burnout, particularly since the maximum heat flux occurs near the intersection of the horizontal and riser pipes (as shown in Figure 21.5.4.3-1b).

GE Response

Isometric drawings are shown below in Figure 1.

The piping arrangement will be such that the sumps will be at the far end of the central (longest) channels. The sumps will be shaped so as to "form" around the pedestal walls with a minimal side exposure. A specially shaped piping jacket in the detailed design will provide coverage of this limited side area of the sumps. Table 21.5.4.3.1 of NEDO-33201 Rev 1 Section 21shows that the whole quantity of core debris and 160 tons of metals all in molten state would be needed to begin to cover the vertical portion of the central channels at this location. Thus there are no issues about the CFD modeling this area, and there are no issues about the sumps receiving significant thermal loads in this design. The sidewall coverage was put in the design to provide extra margins of protection against asymmetries and potentially small thermal loads, which nevertheless would be good to have. To optimize the design in this respect we must wait for the BiMAC tests, so as to learn the (CHF) tolerance of the design to smaller pipe inclination angles, which will interact with the vertical positioning of the sumps on the floor, but this, given the tolerance to CHF, is normal engineering design practice best left for the COL stage.

Similarly, the near edge channels will need special consideration in the detailed design. Again, as Table 21.5.4.3.1 shows the vertical segments of these channels will be exposed to melt with the first quantities that arrive onto the BiMAC, and they will be exposed to thermal loads if any of these quantities remain molten for a sufficiently long time to deplete the sacrificial material that will be provided on these pipes. On modeling natural convection loads nothing special, beyond to what was done already, is needed, and yes the thermal loads are high locally (as explained in the report) but this is the area that is best protected against CHF, as we have learned from the ULPU experience. The reason is that the same mechanism that if present would produce the high thermal loads would also be responsible for thermally loading the vertical portions of the channels, thus driving strong natural circulation flows and thus making the CHF in the short, inclined channels such as for low quality, "forced convection flow. We expect the CHF in this location to be over 1,000 kw/m2, and this we will know for sure soon by BiMAC testing.

DCD Impact

There are no DCD Revisions resulting from the response to this RAI.

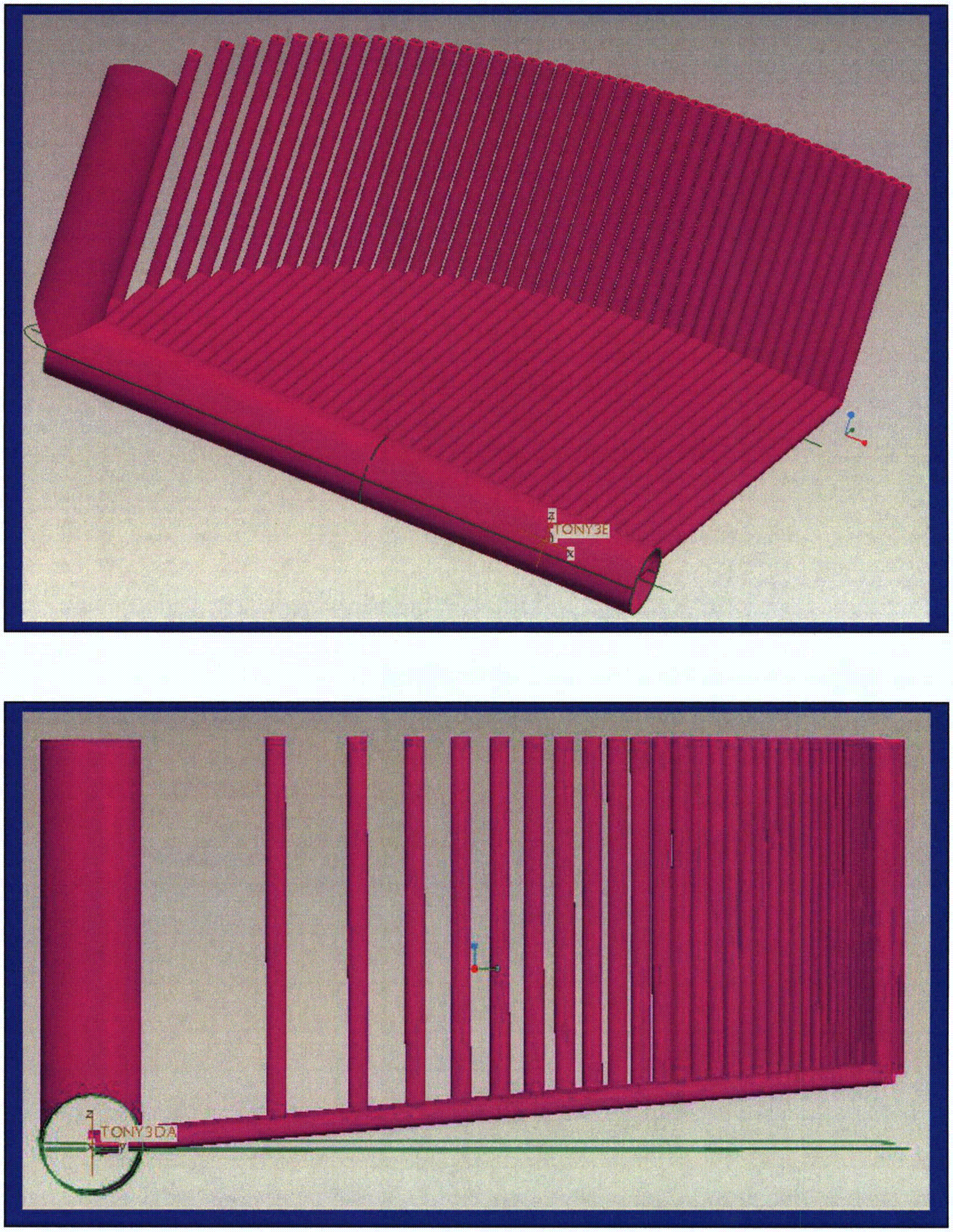


Figure 1. Isometric drawings of the BiMAC piping system. For the near-edge channels in the detailed design the connection will be to rectangular vertical channels shaped so as to cover the wall completely.

NRC RAI 19.2-32

Provide an assessment of the potential for RPV pedestal failure given failure of BiMAC and continued corium-concrete interaction (CCI). Provide plots of concrete ablation in the vertical and horizontal directions as a function of time for both limestone and basaltic concrete. Provide an assessment of whether the structural integrity of the reactor pedestal/RPV would be maintained under these conditions.

GE Response

Sensitivity studies using MAAP were performed to estimate concrete ablation for 3 cases with both limestone and basaltic concrete. These cases involved a loss of injection with successful depressurization of the RPV.

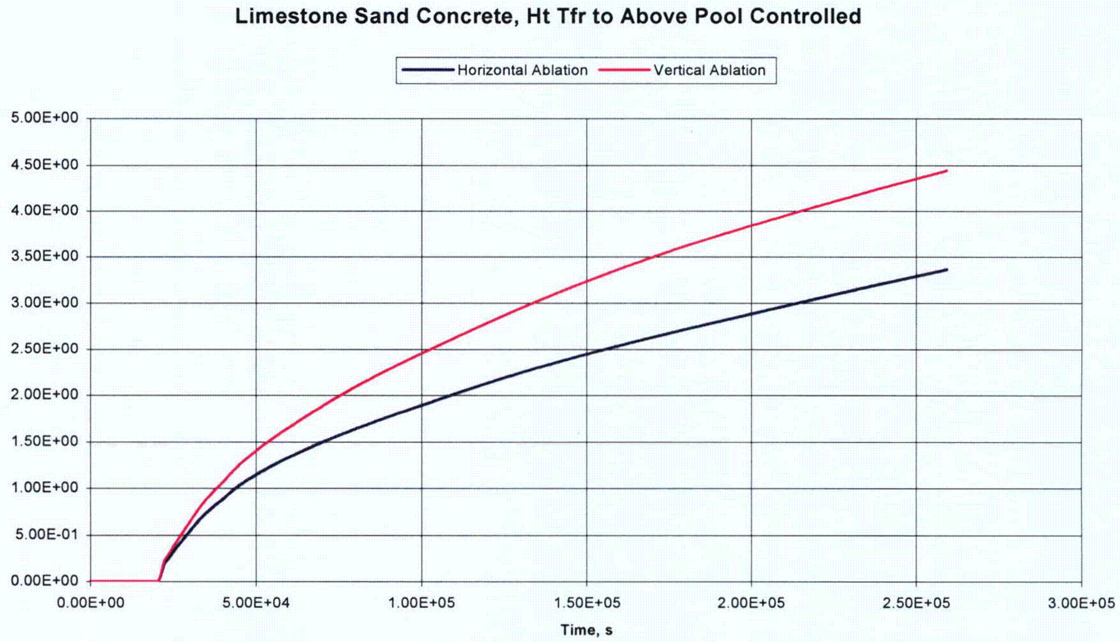
Since detailed structural analysis has not been completed for the ESBWR containment, the ABWR PRA was reviewed for insights into the probability of pedestal failure. The ABWR PRA determined that the lower limit for the amount of radial erosion, which can be sustained without pedestal structural failure, is 1.55 m of the 1.7 m pedestal wall thickness or 91%. This equates to 2.28 m of the 2.5 m ESBWR pedestal thickness.

The 3 sensitivity cases involved the following:

1. dry (CCI) – deluge system does not actuate to flood lower drywell floor
2. minimum heat transfer between corium debris pool and overlying water pool – deluge system does flood lower drywell. MAAP parameter to influence heat transfer from the corium debris pool to overlying pool is set at lowest value in the suggested range.
3. default heat transfer between corium debris pool and overlying water pool – same as 2 except suggested default value is used.
4. heat transfer between corium debris pool and overlying water pool was controlled to obtain a heat transfer rate of 200kWt/m2.

The results are shown in the table below and the horizontal and vertical ablation plots for case 4 are shown below. Note that RPV failure occurs at approximately 20,000 seconds in the sensitivity cases.

Case	Time to Horizontal Ablation = 1.25m	Time to Horizontal Ablation = 2.5m
Basaltic Dry	35,287 s	83,417 s
Limestone Dry	46,973 s	146,593 s
Basaltic Min Heat Trnfr	57,842 s	166,681 s
Limestone Min Heat Trnfr	58,185 s	161,015 s
Basaltic Default Ht Trnfr	Max ablation = 0.32 m	N/a
Limestone Min Heat Trnfr	Max ablation = 0.23 m	N/a
Basaltic Controlled Ht Tfr	38,989 s	90,873 s
Limestone Controlled Ht Tfr	55,405 s	155,729 s


Limestone Sand Concrete, Ht Tfr to Above Pool Controlled
Horizontal Ablation
Vertical Ablation
5.00E+00
4.50E+00
4.00E+00
3.50E+00
3.00E+00
2.50E+00
2.00E+00
1.50E+00
1.00E+00
5.00E-01
0.00E+00
0.00E+00
5.00E+04
1.00E+05
1.50E+05
2.00E+05
2.50E+05
3.00E+05
Time, s


Basaltic Concrete, Ht Tfr to Above Pool Controlled
Horizontal Ablation
Vertical Ablatioin
Ablation Depth, m
7.00E+00
6.00E+00
5.00E+00
4.00E+00
3.00E+00
2.00E+00
1.00E+00
0.00E+00
0.00E+00
5.00E+04
1.00E+05
1.50E+05
2.00E+05
2.50E+05
3.00E+05
Time, s

DCD Impact

No DCD changes will be made in response to this RAI.

NRC RAI 19.2-36

Provide pressure drops and form loss coefficients along the reactor core, specifically: (a) from 3.963 m (bottom of the core plate) to 4.405 m (bottom of active fuel). (b) from 4.405 m (bottom of active fuel) to 5.4211 m, (c) from 5.4211 m to 6.4372 m, (d) from 6.4372 m to 7.453 m, and (e) from 7.453 m (top of Active fuel) to 7.896 m (top of fuel assembly). Note that all elevations are relative to the bottom (inner) of RPV lower head.

GE Response

The pressure drop profile along the reactor core (inside fuel channel) varies from fuel channel to fuel channel. Table 19.2-36-1 contains the data for two typical channels (one central channel and one peripheral channel) at rated reactor power. The pressure drop data are from TRACG. Note that rated reactor conditions contain a core flow window, as indicated in Table 4.4-1 of the DCD Tier 2. The total core flow rate for the data below is 10150 kg/s, which is within this window. The total bypass flow is 12.7% of the core flow. This includes leakage flow bypassed through the lower core plate, leakage flow from the lower tie plate, and water rod flow.

Table 19.2-36-1 Core Pressure Drops and Form Losses

	Central Channel		Peripheral Channel	
Elevation (m AVZ)[1]	Pressure Drop (Pa)	Loss Coefficient (K_N)[3]	Pressure Drop (Pa)[2]	Loss Coefficient (K_N)[3]
3.963[5]	0	0.000	0	0.000
4.405	23195	[[ ]][4]	39335	[[ ]][4]
5.4211	12645	[[ ]]	9563	[[ ]]
6.4372	14282	[[ ]]	7632	[[ ]]
7.453	11820	[[ ]]	5779	[[ ]]
7.896	4625	[[ ]]	4259	[[ ]]

1. The elevations shown are consistent with the NRC request. Pressure data from TRACG is given at different elevations. The data are adjusted based on the static head using the density weighted by the void fraction (Reasonable when frictional losses are small relative to local losses).
2. For simplicity, the vessel pressure calculated by TRACG above and below the core is averaged to generate this data. This causes the total pressure drop over the channels to be the same (66.57 kPa). TRACG predicts a slight variation from channel to channel due to the detailed vessel model in the lower plenum and chimney regions. This variation is discussed in more detail in the GE response to RAI 4.4-39 submitted in MFN 06-350.
3. All loss coefficients are normalized to a flow area (A_N) of 6.452×10^{-3} m^2 (10 in^2). For any given area (x) the loss coefficient can be determined by $K_X = K_N * (A_N)^2/(A_X)^2$.
4. The values shown here are from the response to RAI 4.4-14. These inlet losses are based on the active flow (i.e. without the leakage flow) for simplicity.

5. The pressure drops are calculated from the requested elevation. However, the bottom of the core plate is at an elevation of approximately 4.128 m.

DCD Impact

No DCD changes will be made in response to this RAI.

Enclosure 3

MFN 07-013

David Hinds

Affidavit

General Electric Company

AFFIDAVIT

I, David H. Hinds, state as follows:

(1) I am Manager, New Projects, 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 Enclosure 1 of GE letter MFN 07-013, David H. Hinds to NRC, *Response to Portion of NRC Request for Additional Information Letter No. 40 Related to ESBWR Design Certification Application - ESBWR Probabilistic Risk Assessment - RAI Numbers 19.1-11, 19.1-12, 19.1-19, 19.2-7, 19.2-25, 19.2-32, and 19.2-36*, dated January 5, 2007. The proprietary information in Enclosure 1, Response to Portion of NRC Request for Additional Information Letter No. 40 Related to ESBWR Design Certification Application - ESBWR Probabilistic Risk Assessment - RAI Numbers 19.1-11, 19.1-12, 19.1-19, 19.2-7, 19.2-25, 19.2-32, and 19.2-36, is delineated 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 2.390(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 2.390 (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 results of TRACG analytical models, methods and processes, including computer codes, which GE has developed, and applied to perform Core Form Loss Coefficient evaluations for the ESBWR. GE has developed this TRACG code 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 Core Form

Loss Coefficient evaluations for the BWR was achieved at a significant cost, in excess of one quarter million dollars, to GE.

The development of the testing and 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 10th day of January 2007.

David H. Hinds
General Electric Company