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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 08-692

Docket No. 52-010

September 17, 2008

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. 161 – Related to ESBWR Design Certification Application – RAI Number 21.6-112

The purpose of this letter is to submit the GE Hitachi Nuclear Energy (GEH) response to the U.S. Nuclear Regulatory Commission (NRC) Request for Additional Information (RAI) sent by the Reference 1 NRC letter. GEH response to RAI Number 21.6-112 is addressed in Enclosures 1, 2 and 3.

Enclosure 1 contains GEH proprietary information as defined by 10 CFR 2.390. GEH customarily maintains this information in confidence and withholds it from public disclosure. Enclosure 2 is the non-proprietary version, which does not contain proprietary information and is suitable for public disclosure.

The affidavit contained in Enclosure 3 identifies that the information contained in Enclosure 1 has been handled and classified as proprietary to GEH. GEH hereby requests that the information in Enclosure 1 be withheld from public disclosure in accordance with the provisions of 10 CFR 2.390 and 10 CFR 9.17.

If you have any questions or require additional information, please contact me.

Sincerely,

Richard E. Kingston

Richard E. Kingston
Vice President, ESBWR Licensing

D068
NRO

References:

1. MFN 08-228, Letter from U.S. Nuclear Regulatory Commission to David H. Hinds, GEH, *Request For Additional Information Letter No. 161 Related To ESBWR Design Certification Application*, dated March 7, 2008

Enclosures:

1. MFN 08-692 – Response to Portion of NRC Request for Additional Information Letter No. 161 – Related to ESBWR Design Certification Application – RAI Number 21.6-112 – GEH Proprietary Information
2. MFN 08-692 – Response to Portion of NRC Request for Additional Information Letter No. 161 – Related to ESBWR Design Certification Application – RAI Number 21.6-112 – Non-Proprietary Version
3. MFN 08-692 – Response to Portion of NRC Request for Additional Information Letter No. 161 – Related to ESBWR Design Certification Application – RAI Number 21.6-112 – Affidavit

cc:	AE Cubbage	USNRC (with enclosure)
	RE Brown	GEH/Wilmington (with enclosure)
	DH Hinds	GEH/Wilmington (with enclosure)
	eDRF	0000-0084-1190 and 0000-0084-1169

Enclosure 2

MFN 08-692

Response to Portion of NRC Request for

Additional Information Letter No. 161

Related to ESBWR Design Certification Application

RAI Number 21.6-112

Non-Proprietary Version

NRC RAI 21.6-112

Address noncondensable gas and steam moisture flow in the GDCS lines.

A. *During GDCS injection into the reactor during a LOCA, the downcomer level could be below the GDCS vessel inlet. Could the noncondensable/steam mixture flow back up the pipe? Would that change the hydrostatic head in the pipe? Does TRACG have adequate models to capture this phenomenon? Justify your arguments.*

B. *Please discuss how the GDCS injection lines will be designed and installed (venting features) to ensure that non-condensable gases will not collect in the lines and how design and installation and design parameters that prevent collection of non-condensable gases in the lines will be verified through periodic testing and ITAAC.*

GEH Response to RAI 21.6-112 Part A

(A.1) Summary Response:

- Steam and noncondensable gases cannot flow from the vessel into and up the Gravity-Driven Cooling System (GDCS) line to degrade the GDCS flow for reasons indicated in Sections A.2, A.3 and A.4.
- A listing of TRACG capabilities related to Countercurrent Flow Limiting (CCFL), stratified flow, and treatment of noncondensables is included in Section A.5.
- TRACG sensitivity cases that address possibility of any GDCS flow degradation due to resident non-condensable gases in GDCS injection lines are described in Sections A.2 and, A.3. It is shown that even when the GDCS lines are initially filled with 100% non-condensables, the large GDCS static head flushes out the non-condensables and establishes full flow.
- Sustained CCFL does not occur and does not degrade the GDCS flow in any significant way, as discussed in Section A.4. This is because the steam condensing capacity of GDCS flow is very large and the cold GDCS fluid condenses all steam before it can cause any significant GDCS flow degradation due to CCFL. Available experimental data in Reference [3] shows that under similar subcooling conditions, subcooled water condenses steam rapidly and fills a 73 mm diameter pipe in about 8 seconds, indicating rapid filling and that there is no steam binding.

(A.2) Venting Friendly GDCS Line Routing: As indicated in Part B of the response, and shown in DCD Tier 2 Figure 6.3-1, the water loop seal in the GDCS line will prevent transfer of noncondensable gases through the GDCS piping. The sloping of GDCS piping away from the high points will prevent gas accumulation by promoting venting of any non-condensable gases. Figure 21.6-112-A1 shows a routing diagram of the GDCS system, and one of the four divisions are indicated by the red arrows. The GDCS line connects the GDCS pool and the Reactor Pressure Vessel (RPV).

(A.3) Large GDCS Static Head Flushes Out Non-Condensables: The hydrostatic head that drives the GDCS flow from the GDCS pool to the RPV is on the order of [[ ]]. This driving head will flush out any non-condensable gases in the GDCS injection line. TRACG sensitivity studies have been performed with significant amount of non-condensable gases artificially placed in the GDCS line as discussed in Section A.5 of this response. In one of these sensitivity studies, a GDCS line break LOCA was simulated with the intact GDCS lines completely filled with noncondensable gases. As shown below, these sensitivity studies confirm insignificant degradation of GDCS flow.

(A.4) Countercurrent flow limiting (CCFL) does not impede the GDCS flow due to reasons below.

a) The initial GDCS flow is submerged in the downcomer liquid, and there is no possibility of CCFL. For the GDCS Line Break bounding LOCA case GDL4A_1DPVLB, the GDCS flow initiates when the downcomer two-phase level is still above the elevation of GDCS line entry to the RPV. This submergence is confirmed from Figure 21.6-112-A2 which shows the downcomer two-phase level response, and the Figure 21.6-112-A3 which shows the GDCS flow response.

b) When the downcomer water level recedes below the GDCS nozzle elevation, steam flows towards the cold water in the GDCS line, and condenses. The steam condensing capacity of the flow from the intact GDCS lines exceeds the rate at which steam flows towards the cold water, by a factor of two to three. The GDCS injection flow is highly subcooled corresponding to vessel saturation conditions. This large subcooling ranges from [[ ]]. This was confirmed from the TRACG output of the DCD Tier 2 GDCS Line Break LOCA case. The excess steam condensing capacity of the cold GDCS water implies that all steam in the vicinity of the GDCS flow entering the RPV is condensed.

c) A TRACG sensitivity calculation (**Case 1**) was performed with the CCFL flag turned on for the GDCS Drain Line Break LOCA case GDL4A_1DPVLB. TRACG calculation results indicate an initial period of about 15 seconds when there is some countercurrent flow at the injection nozzle; however, the flow becomes cocurrent after this short period as the cold GDCS fluid condenses all steam entering into the drain line. The comparison of GDCS flows between Case 1(with CCFL flag turned on), and Case 1B(without CCFL flag turned on), indicates insignificant effect of CCFL on the total GDCS flow, as shown in Figure 21.6-112-A4.

d) Figure 21.6-112-A5 includes information from published test data in Reference [3]. The test facility consists of a 73 mm diameter pipe where steam is injected at the upper right and cold (subcooled) water is injected in the lower left. The test conditions are at 30 bars. There are four temperature measurement stations T1 through T4 as shown in the sketch. The temperature traces at the stations T1 through T4 indicate that the liquid successfully condenses the steam and fills the pipe in about 8 seconds. The key takeaway is that there is no indication of CCFL in these traces as well as from the CFD simulation plots that are included in the original paper in Reference [3].

(A.5) TRACG Sensitivity Study with Non-Condensable Gases in GDCS Lines and Pool

TRACG sensitivity cases were run using the GDCS Line Break bounding LOCA case as a base case. The following initial conditions were used. Case 1B is the base case. Cases 2 and 3 represent large, and highly unlikely initial noncondensable fractions in the GDCS lines, and are simulated to study the limiting effect on GDCS flow. The sensitivity study in Case 2 addresses a suggestion made by several ACRS members at the May 8, 2008 ACRS Full Committee Meeting in Washington DC where GEH presented initial results of GDCS line noncondensable sensitivity. In Cases 2 and 3, the non-condensable mixture was placed on both sides of the initially closed GDCS line squib valve.

The summary of the sensitivity study is captured in Figure 21.6-112-A6.

- **Case 1B – (Base Case)** GDL Break LOCA with failure of one DPV. No noncondensable gas in the GDCS line or mixed with the liquid in GDCS pool.
- **Case 2 – (100% NC Case)** the liquid in the GDCS injection line is completely replaced with noncondensable gases.
- **Case 3 – (30% NC Case)** GDCS line contains 30% noncondensable gases by volume. Additionally, the static head in the GDCS pool is effectively reduced by 30% by replacing the water with a mixture of 70% water and 30% noncondensable gases (air) by volume. The two-phase level tracking model in TRACG was turned off to provide additional barrier to phase separation in the pool, thus modeling an initial bubbly mixture of air and water in the GDCS pool. The purpose is to see if the noncondensables can vent to the GDCS pool surface, and the effect on GDCS flow of any non-condensable gases drawn into the GDCS line after the onset of GDCS injection.

The summary of the sensitivity study is captured in Figure 21.6-112-A6 where the transient GDCS flow response is plotted. The effect of initial non-condensable gases, resident in the GDCS line on the GDCS flow is negligible. Also, the behavior is similar when both the GDCS line and the GDCS pool are 30% non-condensable mixtures. In the later case the imposed initial condition of 30% void in the GDCS pool translates to 70% initial inventory and static head in the GDCS pool. This initial reduction of static head in the GDCS pool, as expected, reduces the peak GDCS flow rate by a small amount, 8 to 10%.

Figure 21.6-112-A7 shows the transient void fraction in the GDCS line at various locations upstream of the GDCS squib valve for Case 2 where the GDCS line is full of noncondensable gas (air). It is seen that the noncondensables vent from the GDCS line and to the GDCS pool (as this is the only path in the TRACG Nodalization, with the squib valve closed). After the squib valve opens and GDCS flow to the RPV commences, the GDCS flow drives out the remaining non-condensables to the RPV in less than 30 seconds. The effect on the GDCS mass flow rate is insignificant.

(A.6) TRACG Capabilities: TRACG has qualified models to capture the phenomena described in Sections A.1 through A.5 above, References [1], and [2]. The most

relevant models are listed below with Sections numbers from TRACG Model Description, Reference [2], in parenthesis.

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References:

1. TRACG Model Description, NEDE-32176P, Revision 3, April 2006
2. TRACG Qualification, Licensing Topical Report, NEDE-32177P, Revision 3, August 2007
3. Luka Strubelj and Iztok Tiselj, "Numerical Modeling of Condensation of Saturated Steam On Subcooled Water Surface in Horizontally Stratified Flow", The 12th International Meeting on Nuclear Reactor Thermal Hydraulics (NURETH-12), Pittsburg, Pennsylvania, USA, 2007

GEH Response to NRC RAI 21.6-112 Part B

GDCS injection lines run from GDCS pools to RPV inlet nozzles, where the GDCS pool outlets are at higher elevation than the RPV inlet nozzles. DCD Tier 2, Figure 6.3-1 illustrates this relationship. There are four trains of injection lines for the GDCS. DCD Tier 2, Table 6.3-2 contains the minimum elevation change between the GDCS pool surface and the RPV nozzles that assure the pool outlet is higher than the RPV nozzles.

Each train of GDCS 8-inch injection line with an isolation valve, which begins from GDCS pool outlet, is routed down first making a 4-inch branch for deluge line and then two 6-inch branches for injection lines. Each 6-inch GDCS injection branch line pipe route makes a U-shape bottom loop at the lowest elevation before rising up to tie into the RPV nozzle. There is no elevated piping loop above GDCS outlet and RPV inlet nozzle levels.

The bottom section of each 6-inch pipe loop is at the lowest elevation with reference to GDCS pool outlet elevation and RPV nozzle inlet elevation. The bottom loop design prevents collection of non-condensable gases at the bottom of the injection line pipe.

A squib valve is located at the bottom of each U-shape pipe loop. There is an open check valve upstream of the squib valve and an open block valve downstream of squib valve. During normal operation the injection line squib valve stays closed and pipe legs on both sides of squib valve are filled with water. The water solid pipe leg from squib valve to RPV inlet nozzle prevents non-condensable gases entering into the pipe.

The GDCS injection line section from squib valve to GDCS pool is self-venting back to the pool, which is at the highest elevation of the system. Each GDCS pool is sufficiently vented to the drywell gas space.

There are two 1-inch test lines on each 6-inch injection pipe, one on each side of squib valve. Each test line has two isolation valves. They stay closed during normal operation. Test lines stay filled with liquid up to isolation valves. Test lines are for test/black flush during refueling outages.

A new ITAAC (ITAAC No. 24) was added to DCD Revision 5 Tier 1, Design Description and Table 2.4.2-3, for the inspections of GDCS injection piping installation to verify that the as-built piping installation conforms to design that allows venting of non-condensable gases to GDCS pools and to RPV, to prevent collection in the GDCS injection pipes.

DCD Impact

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

No changes to the subject LTR will be made in response to this RAI.

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Figure 21.6-112-A1 GDCS Routing Schematic

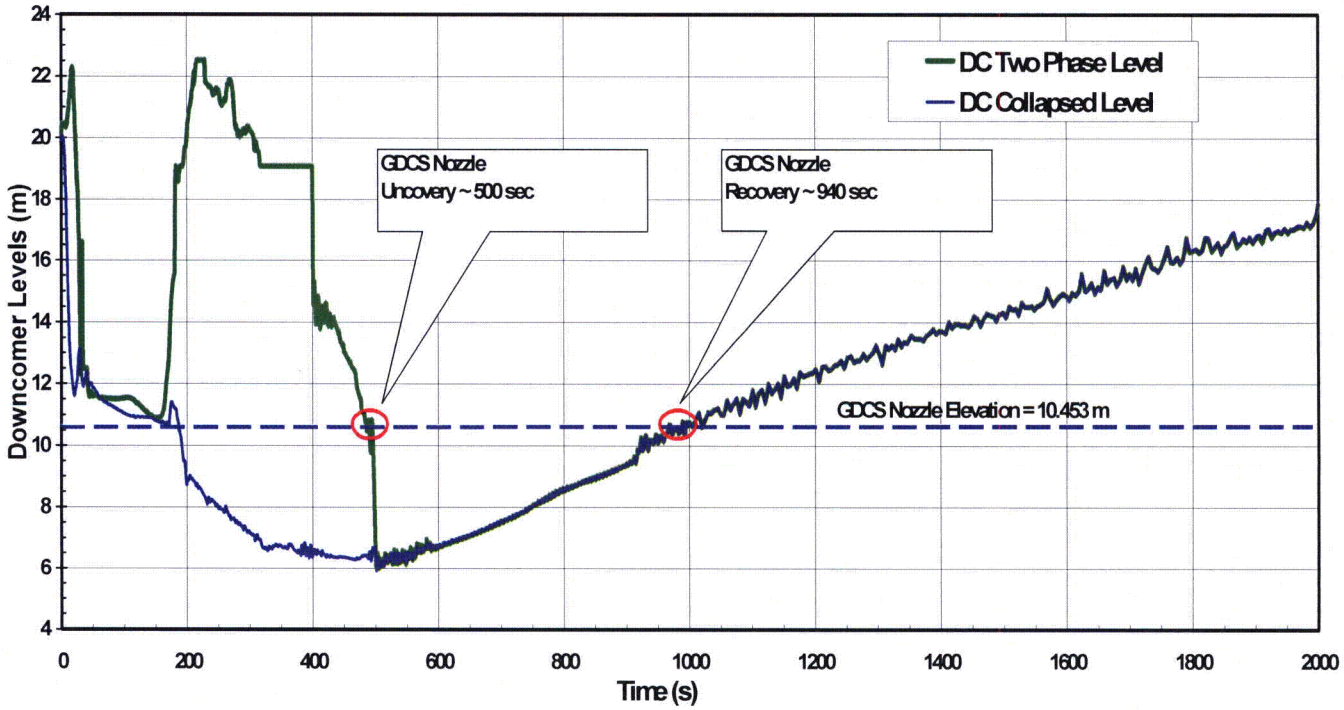

Figure 21.6-112-A2 GDCS Flow – GDL Break LOCA (Bounding Case, Case 1B)

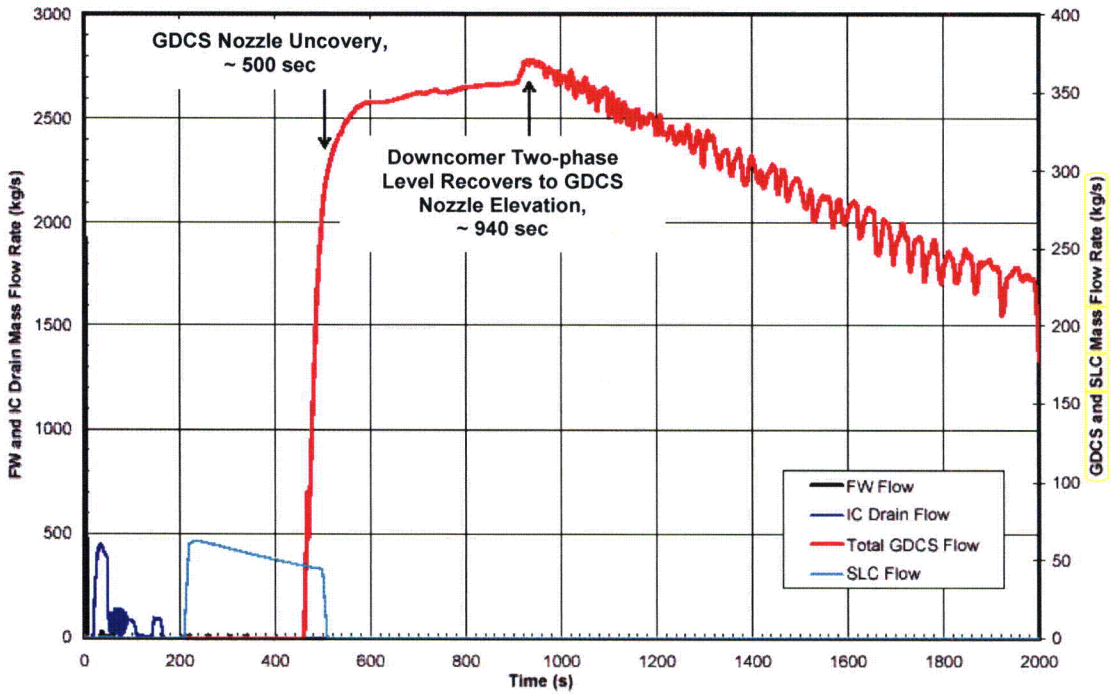

Figure 21.6-112-A3 GDCS Flow – Gravity Drain Line Break LOCA, Case 1B)
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Figure 21.6-112-A4 GDCS Flow - CCFL Sensitivity – Gravity Drain Line Break LOCA Bounding Cases (Case 1 vs. Case 1B)

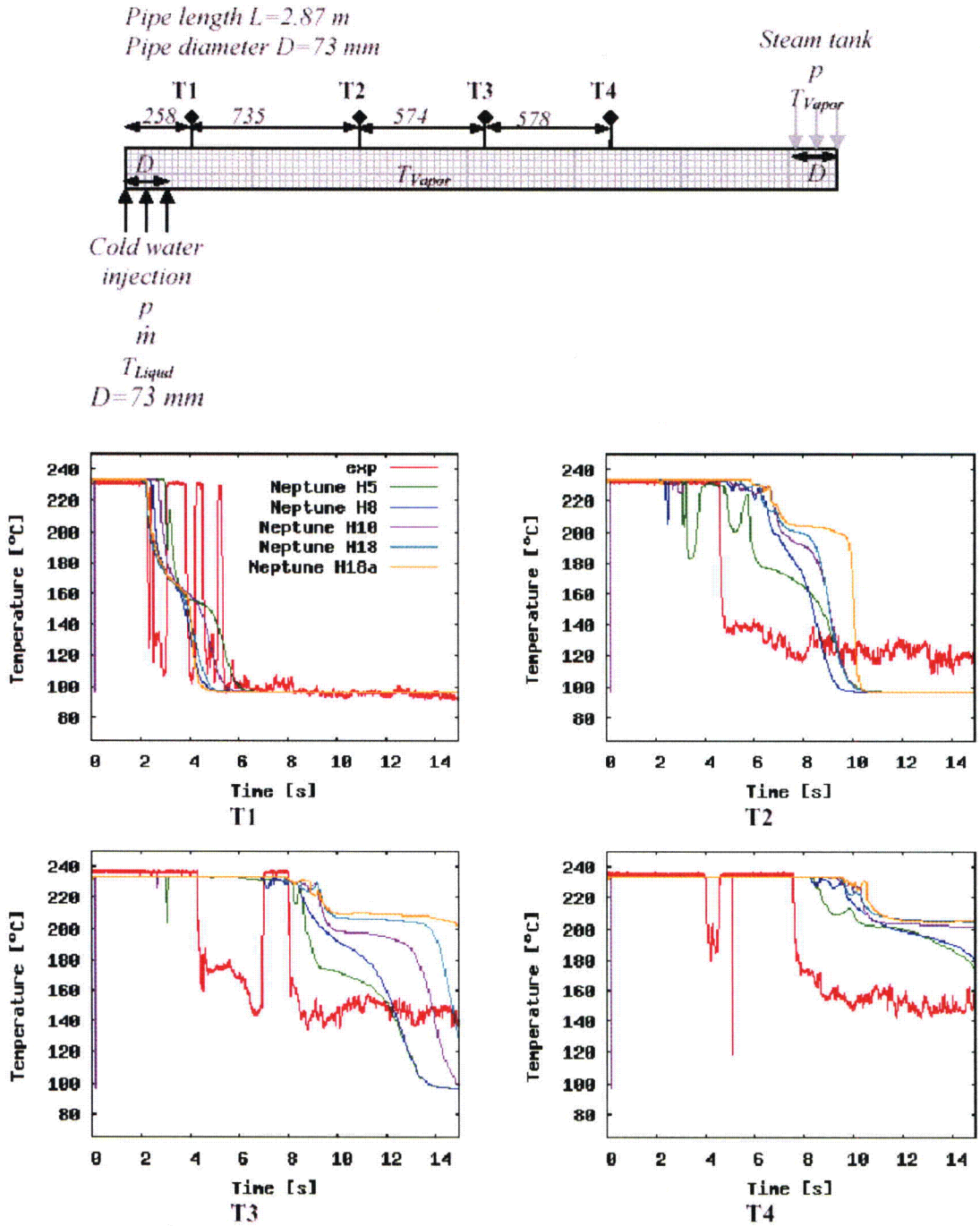

Figure 8 Local temperatures in experiment and simulation with Neptune_CFD on different grids.

Figure 21.6-112-A5 Cold Water Quickly Fills a Steam Filled Pipe

(PMK-2 Tests, Figure 8 from Reference 3, Copyright: American Nuclear Society)

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Figure 21.6-112-A6 TRACG Sensitivity - Effect of Initial Non-condensable Void Fraction in GDCS Lines and GDCS Pool on Total GDCS Flow to RPV (GDCS Line Break LOCA Bounding Cases

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Figure 21.6-112-A7 Onset of GDCS Flow Flushes Out all Noncondensables from GDCS Line to RPV (initially the GDCS line full of noncondensable gases (N_2), Case 2)

Enclosure 3

MFN 08-692

Response to Portion of NRC Request for

Additional Information Letter No. 161

Related to ESBWR Design Certification Application

RAI Number 21.6-112

Affidavit

GE-Hitachi Nuclear Energy Americas LLC

AFFIDAVIT

I, David H. Hinds, state as follows:

(1) I am General Manager, New Units Engineering, GE Hitachi Nuclear Energy ("GEH"), 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 GEH's letter, MFN 08-692, Mr. Richard E. Kingston to U.S. Nuclear Energy Commission, entitled "*Response to Portion of NRC Request for Additional Information Letter No. 161 – Related to ESBWR Design Certification Application – RAI Number 21.6-112,*" dated September 17, 2008. The proprietary information in enclosure 1, which is entitled "*MFN 08-692 – Response to Portion of NRC Request for Additional Information Letter No. 161 – Related to ESBWR Design Certification Application – RAI Number 21.6-112 – GEH Proprietary Information,*" is delineated by a [[dotted underline inside double square brackets{3}]]. 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 or licensee, GEH 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 GEH's competitors without license from GEH 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 GEH customer-funded development plans and programs, resulting in potential products to GEH;

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 GEH, 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 GEH, 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, or subject to the terms under which it was licensed to GEH. Access to such documents within GEH 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 for technical content, competitive effect, and determination of the accuracy of the proprietary designation. Disclosures outside GEH 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, that GEH has developed and applied to ESBWR Loss of Coolant Accident (LOCA) response evaluations. GEH has developed this TRACG code for over fifteen years, at a significant cost. The reporting, evaluation and interpretation of the results, as they relate to the LOCA response evaluations for the ESBWR was achieved at a significant cost to GEH.

(9) Public disclosure of the information sought to be withheld is likely to cause substantial harm to GEH's competitive position and foreclose or reduce the availability of profit-making opportunities. The information is part of GEH'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 GEH.

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.

GEH's competitive advantage will be lost if its competitors are able to use the results of the GEH 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 GEH 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 GEH of the opportunity to exercise its competitive advantage to seek an adequate return on its large investment in developing and obtaining 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 17th day of September 2008.

David H. Hinds
GE-Hitachi Nuclear Energy Americas LLC