Enclosure 1

MFN 16-034

GEH's Response to RAI 06.03-2

NRC Request for Information RAI 06.03-2:

In RAI 06-03-1, in accordance with 10 CFR 52.59(a) (2014), the NRC staff requested GE Hitachi Nuclear Energy (GEH) to provide information showing that the ECCS suction strainer design complies with 10 CFR 50.46(b)(5) (1997). GEH responded in letters, dated April 8, 2015, and July 17, 2015. The staff's review of the applicant's response found the need for additional information as cited below.

A. Design and Analysis of ECCS Strainer

1. *To enable making a safety determination with respect to 10 CFR 50.46(b)(5), the staff needs the applicant to provide its evaluation of ECCS strainer performance (e.g. head loss) and the results of any analysis and/or tests performed in support.*

2. *GEH updates the design to install reflective metal type insulation on the ASME Section III, Class 1 piping greater than 80 mm in the drywell. As pointed out by GEH, use of reflective metal type insulation improves the design by reducing the potential suction strainer debris load and clogging. However, the types and quantities of insulation debris being transported to the ECCS suction strainers and the core following a design basis accident are needed for evaluating the ECCS and core design. Staff needs a design basis debris load in the DCD to enable the staff to make the 50.46(b)(5) finding.*

3. *GEH's response deletes the following without providing an alternate description of the debris strainers: "The ABWR ECCS suction strainers will utilize a 'T' arrangement with conical strainers on the 2 free legs of the 'T'. This design separates the strainers so that it minimizes the potential for a contiguous mass to block the flow to an ECCS pump." Staff needs sufficient design detail to assess the performance of the system under the accident conditions. For example, staff would need to understand the strainer type, flow area, and hole size to assess strainer head loss. (See Regulatory Positions C.2.1.2.1 and C.2.1.2.2 of RG 1.82 rev 3.) This combined with the information in response to Question 1 would enable staff to assess the head loss due to debris and enable the staff to make a finding on compliance with 10 CFR 50.46(b)(5).*

4. *GEH's response deletes Tables 6C-1 and 6C-2 which provide debris analysis input parameters and results of ECCS debris strainer sizing analysis without providing alternate tables or references to calculation reports. Staff needs the type of information from these tables to be provided in the DCD to support the staff's safety finding.*

5. *GEH's response provides references to guidance documents, e.g., "Of the debris generated, the amount that is transported to the suppression pool shall be determined in accordance with Reference 6C-3 based on similarity of the Mark III upper drywell design." However, the response does not provide the ECCS debris strainer design input calculated using these guidance documents nor does it reference calculation reports providing such information. Staff requests GEH provide the analysis documenting the implementation of this guidance be made available for staff audit and the summary of the inputs methods and results be placed on the docket.*

B. Chemical Effects

The staff requests the following additional information about how the potential for chemical effects is addressed through design, to enable the staff to make the safety finding for 10 CFR 50.46(b)(5).

1. *There is currently a limited understanding of chemical precipitation under the anticipated range of post-loss-of-coolant accident (LOCA) chemical and temperature conditions for Boiling Water Reactors. An investigation suggested corrosion products from steel and zinc may have contributed to head loss across a bed of mineral wool on the strainer in a test facility ("Influence of Corrosion Processes on the Protected Sump Intake after Coolant Loss Accidents," Nuclear Technology Annual Convention 2006, translated from German, ADAMS Accession No. ML083510156). Research on pressurized water reactor (PWR) chemical effects has shown aluminum, calcium silicate, concrete, and silicon-rich insulation materials can form chemical precipitates under conditions similar to BWR post-LOCA conditions. Since the amount of chemical precipitation would depend, in part, on the amount of the contributing materials in communication with the ECCS, the staff requests that you describe the use of the following materials in the ABWR containment and how the design establishes limits on the quantities of:*

   a. *Aluminum*
   b. *Metallic zinc, including galvanized steel*
   c. *Inorganic zinc-rich coatings*
      i. *All unqualified*
      ii. *Qualified and not topcoated within 10D zone of influence of a piping system break location*
      iii. *Qualified and epoxy topcoated within 4D zone of influence of a piping system break location*
   d. *Uncoated carbon steel*
   e. *Concrete*
      i. *Uncoated*
      ii. *Coated and within the zone of influence for the coating*
   f. *Insulation other than reflective metal insulation (i.e., fiberglass, calcium silicate, mineral wool, amorphous silica, etc.)*

2. *Since chemical precipitation depends on the temperature and chemical environment, provide the ranges and timing of pH, pool temperature, and boron concentration possible following a loss of coolant accident. Include the timing of the Standby Liquid Control System initiation. In addition, identify where this information is found in the DCD.*

3. *Identify and justify how the strainer and fuel assembly performance criteria will be met, considering chemical precipitates that may form under the conditions described above (bounding or plant-specific).*

C. Downstream Effects

1. *Similar to question A.2 above, staff needs an in-vessel design basis debris load in the DCD that will establish the design basis limits for in-vessel testing. This will enable the staff to make the 50.46(b)(5) finding.*

2. *A justification for the acceptability of the core design with respect to core cooling in the presence of debris should be provided. GEH should provide testing results and/or analysis to support its design. Any justification for reliance on historical testing should be accompanied by a justification of the applicability of the referenced tests to the GE-7 fuel specified in the certified design.*

3. *GEH should provide the ABWR-specific acceptance criteria it relied upon in evaluating the test and/or analysis results.*

GEH Response to RAI 06.03-2:

A. Design and Analysis of ECCS Strainer

1. The ABWR ECCS strainers will be the GE stacked disk design in accordance with NEDC-32721P-A Rev. 2 (ML031010392). This report, which was reviewed and approved by the NRC, describes methods for sizing a stacked disk suction strainer and evaluating the head losses due to debris accumulation. The DCD will be updated to include a general description of the stacked disk strainer, and to remove obsolete information related to the T-shaped conical strainer, and outdated information such as the guidance to design for 50% plugging.

   As supporting basis to the DCD content, an evaluation has been performed on an existing designed stacked disk strainer design from the operating BWR fleet to assess its ability to meet the requirements of the ABWR ECCS systems. The evaluation demonstrates that the head loss across the strainer under the design basis debris load (discussed below) is within an acceptable limit such that the required NPSH can be supplied to the ECCS pumps. The design chosen for this evaluation is used only as an example to demonstrate the concept, and it is not intended to be prescriptive of the actual sizing of the ABWR strainers.

2. The ABWR DCD will be updated to include the following table that lists the types and quantity of debris determined in accordance with Utility Resolution Guidance (URG) NEDO-32686-A (ML092530482). The spherical zone of influence (ZOI) was used to determine quantities of pipe insulation (both RMI and Nukon fiber):

Debris Type	Strainer Load
Sludge / corrosion prod.	90.7 kg (200 lbm)
Inorganic Zinc (IOZ)	21.3 kg (47 lbm)
Epoxy Coated IOZ	38.6 kg (85 lbm)
Rust Flakes	22.7 kg (50 lbm)
Cement Dust / Dirt	68.0 kg (150 lbm)
Reflective Metal Insulation	35.8 m^2 (385 ft^2)
Nukon Fiber Insulation	23.4 kg (51.6 lbm)

ECCS Strainer Debris Load

The non-insulation debris values are as recommended by NEDO-32686-A. The sludge load of 200 lbm is equivalent to 100 lbm/year assuming a two-year cycle. This value was chosen to envelope the survey results reported in URG Section 3.2.4.3.2 in which the median sludge generation rate for operating BWRs was found

to be 88 lbm/year. The ABWR design includes many improvements over the conventional BWRs that will help to minimize the generation of sludge. Specifically,

- The suppression pool is equipped with a stainless steel liner on the normally wetted surfaces, and many interfacing systems utilize stainless steel pipe, which reduces the generation of carbon steel corrosion products.
- The ABWR suppression pool is enclosed in a concrete compartment and protected from the drywell environment, unlike some containment designs from the BWROG survey which have debris sources above the pool that can fall directly in by gravity.
- The Suppression Pool Cleanup System (SPCU) is run periodically during operation to remove suspended impurities, and a method for maintaining suppression pool cleanliness is required by DCD Section 6.2.7.3.

For these reasons, there is reasonable assurance that the ABWR will have significantly less sludge generation than the operating fleet of BWRs, and the selection of 200 lbm (90.7 kg) total is reasonable.

3. The conical strainer design is obsolete and has been updated to the GE stacked disk strainer as explained in the response to item A.1. Design details related to the stacked disk strainer performance and sizing methodology can be found in the report NEDC-32721P-A.

4. The DCD markups now include an updated Table 6C-1 which includes the design basis debris load shown above for Response A.2. This information, combined with the methodology in NEDC-32721P-A, provides the necessary inputs to design a strainer that complies with 10CFR50.46(b)(5).

   The evaluation described in response to item A.1 provides additional details on a conceptual strainer design that satisfies the requirements of the ABWR ECCS systems.

5. The DCD shall be updated as explained in response to item A.1 to reference report NEDC-32721P-A, which provides the strainer design methodology. The evaluation described in response to item A.1 is available for NRC audit.

B. Chemical Effects

1. The material discussion of "Engineered Safety Feature Materials" for the ABWR are given in DCD Chapter 6, Section 6.1. It covers metallic materials and organic materials. Steel is used to line the containment thus isolating the concrete from degradation and preventing dissolution. In that the RAI asks for the use of specific materials these are addressed individually as follows:

   a. Aluminum:
      Aluminum will not be installed in the ABWR containment.
   b. Metallic Zinc:
      Use of exposed metallic zinc is limited to galvanized steel in ladders, ductwork, unistruts, and grating and will not make any significant contribution to corrosion products in the suppression pool.
   c. IOZ Coatings:
      i. All unqualified:
         As stated in the DCD, only small amounts of unqualified IOZ coatings associated with small size equipment will be present. These include electrical trim, face plates and valve handles.
      ii. Qualified and not top-coated:
         None. Zinc rich primer is always coated with a qualified epoxy top coat.
      iii. Qualified and epoxy top coated within 4D zone of influence of a piping system break location:
         The quantity of epoxy coated IOZ is bounded by the guidance of NEDO-32686-A, Section 3.2.2.2.2.1.1 Table 3.
   d. Uncoated carbon steel:
      Uncoated carbon steel will not be used in the ABWR containment.
   e. Concrete:
      i. Uncoated:
         None. As stated, the concrete containment is isolated from the coolant by the steel liner. Uncoated concrete is not used in the ABWR containment.
      ii. Coated and within the zone of influence for the coating:
         None. The quantity of debris generated due to jet impingement on coatings is addressed by Item C above. As mentioned above, all concrete is protected from jet impingement, but a quantity of 150 lbs. of dirt and dust is assumed per the guidance of NEDO-32686-A, Section 3.2.2.2.3, Item 2.
   f. Insulation other than RMI
      The only type of pipe insulation permitted, aside from RMI, is Nukon fiber. The ABWR limits the amount of Nukon by restricting it to pipe sizes of 80 mm and smaller. A calculation is performed per the URG guidance of NEDO-32686-A to determine the quantity of Nukon that is assumed to reach the suppression pool during a LOCA (see Response A.2).

Also see response item C.2, which describes testing for chemical and downstream effects to be performed at a future date, and a COL Item that requires the applicant to evaluate the ABWR design and demonstrate it is bounded by the test conditions and acceptance criteria.

2. Per the DCD Chapter 6, Section 6.1.1.2: "The post-LOCA ESF coolant, which is high-purity water, comes from one of two sources. Water in the 304L stainless steel-lined suppression pool is maintained at high purity (low corrosion attack) by the Suppression Pool Cleanup (SPCU) System. Since the pH range (5.3 - 8.6) is maintained, corrosive attack on the pool liner (304L SS) will be insignificant over the life of the plant. ESF coolant may also be obtained from the condensate storage tank, if available." The Standby Liquid Control System (SLC) is credited to mitigate ATWS events (discussed in DCD Section 15.8), but does not operate during a design basis LOCA. Therefore, for the purpose of suction strainer design, sodium pentaborate is not a contributing factor affecting pool chemistry.

3. The strainer shall be designed as described in response to Part A of this RAI. The debris loading shall be in accordance with the Table shown in response to Item A.2. The downstream effects on the fuel assemblies are discussed more directly in response to Item C of the RAI.

C. Downstream Effects

1. The design basis suppression pool debris load is provided in Table 6C-1 of the DCD.

   A proposed method for analyzing the downstream blockage effects, critical fuel parameters, and acceptance criteria is presented in the Licensing Topical Report NEDE-33608-P Rev. 2, which has been submitted for NRC review. That document determines a limiting baseline LOCA scenario including the extent of fuel inlet blockage vs. time and (pending NRC approval) is typical of the test methodology that will be used to demonstrate adequate coolability under the limiting scenario. Complete guidance from that document will be available following USNRC approval of the BWROG program to successfully address fuel downstream effects for existing licensed plants and fuels.

2. A COL Item shall be added in Appendix 6C that requires the COL Applicant to provide an evaluation that demonstrates how the ABWR design is bounded by the scope of the chemical and downstream effects test program. That evaluation shall identify and account for any non-conservative differences between the ABWR design (including the referenced fuel design and source term for corrosion products) and the conditions used in the test program.

3. Similar to the above, the evaluation provided by the COL Applicant shall include an assessment of the test program acceptance criteria, evaluate the extent to which it is applicable to the ABWR design, and justify any non-conservative differences.

Impact on DCD:

The following ABWR DCD Revision 6 tables and sections are revised as shown in the markups provided in Enclosure 2 as a result of this response:

Tier 1:

- Table 2.4.1: In Item 4c, replaced the 50% blockage criteria with a reference to the analytically derived value for strainer head loss.
- Table 2.4.2: In Item 3g, replaced the 50% blockage criteria with a reference to the analytically derived value for strainer head loss.
- Table 2.4.4: In Item 3j, replaced the 50% blockage criteria with a reference to the analytically derived value for strainer head loss.

Tier 2:

- Table 1.6-1: Added reference to NEDC-32721P-A.
- Table 5.4-2: Replaced the 50% blockage criteria with reference to Appendix 6C.
- Section 6C: Extensive changes as discussed in this RAI response