Enclosure 2

MFN 15-024 Supplement 1

GEH Supplemental Response to RAI 06.03-1

ABWR DCD DRAFT Revision 6 Markups

Table 1.9-1 Summary of ABWR Standard Plant COL License Information (Continued)

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Table 1.9-1 Summary of ABWR Standard Plant COL License Information (Continued)

Item No.	Subject	Subsection
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8.6	Capacity of Auxiliary Transformers	8.2.4.5
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8.10	Protective Devices for Electrical Penetration Assemblies	8.3.4.4

6.12
ECCS Suction Strainer
6C.5.1

The thermal-mechanical design process emphasizes that:

(1) The fuel assembly provides substantial fission retention capability during all potential operational modes.

(2) The fuel assembly provides sufficient structural integrity to prevent operational impairment of any reactor safety equipment.

The fuel assembly and its components are designed to withstand:

(1) The predicted thermal, pressure and mechanical interaction loadings occurring during startup testing, normal operation, and anticipated operational occurrences

(2) Loading predicted to occur during handling

(3) Incore loading predicted to occur from an operational basis earthquake occurring during normal operating conditions

Operating limits are established to ensure that actual fuel operation is maintained within the fuel rod thermal-mechanical design bases. These operating limits define the maximum allowable fuel pellet operating power level as a function of fuel pellet exposure. Lattice local power and exposure capabilities are applied to transform the maximum allowable fuel pellet power level into Maximum Average Planar Linear Heat Generation Rate (MAPLHGR) limits.

The potential for debris bypass of ECCS suction strainers for the ABWR DCD GEH P8x8R fuel design will be bounded by the BWROG GSI-191 committee fuel blockage test program results and application bases (Reference COL Information Item 6C.5.1) since the testing will be evaluated for 10x10 fuel. The ABWR does not have core uncovery during a LOCA and therefore has greater margin than the BWROG test program for fuel debris blockage.

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4.2.1.2 Control ...

The control rod is designed to have:

(1) Sufficient mechanical strength to prevent displacement of its reactivity control material

(2) Sufficient strength to prevent deformation that could inhibit its motion

The detailed design bases for the control rod are provided in Appendix 4C.

4.2.2 Description and Design Drawings

4.2.2.1 [Fuel Assembly

The reference core uses the GEH P8x8R fuel design. Information for this fuel design is provided under Tab AY (ABWR fuel design) of Reference 4.2-1. The fuel assembly is shown in Figure 4.2-1, and consists of a fuel bundle and a channel which surrounds the fuel bundle. The fuel bundle contains 62 fuel rods and two water rods. The fuel and water rods are spaced and

4.2.3.2 Control Rods

4.2.3.2.1 Evaluation Results

The control rod evaluations described in Section 4C.3 have been completed for the reference control rod. The evaluations demonstrate that the criteria of Appendix 4C are satisfied for the reference B_4C control rod.

4.2.4 Testing, Inspection, and Surveillance Plans

GEH has an active program of surveillance of fuel, both production and developmental. [*The NRC has reviewed the GEH program and approved it in Reference 4.2-3.*]*

~~4.2.5~~ 4.2.6 References

4.2-1 [*"GE Fuel Bundle Designs", NEDE-31152P, December 1988.*]*

4.2-2 [*Letter, C. O. Thomas (NRC) to J. S. Charnley (GE), "Acceptance for referencing of Licensing Topical Report NEDE-24011-P Amendment 7 to Revision 6, General Electric Standard Application for Reactor Fuel", March 1, 1985.*]*

4.2-3 [*Letter, L. S. Rubenstein (NRC) to R. L. Gridley (GE), "Acceptance of GE Proposed Fuel Surveillance Program", June 27, 1984.*]

4.2.5 COL License Information

4.2.5.1 Evaluation of Post-LOCA Fuel Bundle Blockage due to ECCS Strainer Debris Bypass

The COL shall evaluate the consequences of debris loading on the fuel bundles to confirm the acceptability of fuel design for application to ABWR. The potential for debris bypass of ECCS suction strainers will be evaluated per COL Information Item 6C.5.1. The fuel design shall be compared against the BWROG GSI-191 committee fuel blockage test program results and application bases (Reference COL Information Item 6C.5.1) to identify and evaluate key differences that could affect blockage of flow through the bundle.

6.C Containment Debris Protection for ECCS Strainers

6C.1 Background

NRC Bulletin No. 93-02, "Debris Plugging of Emergency Core Cooling Suction Strainers," references NRC guidance and highlights the need to adequately accommodate suppression pool debris in design by focusing on an incident at the Perry Nuclear Plant. Similar concerns were later identified throughout the industry and documented by subsequent bulletins and generic letters including NRC Bulletin 95-02, NRC Bulletin 96-03, Generic Letter 97-04, and Generic Letter 98-04. GEH reviewed the concerns addressed by NRC Bulletin 93-02these bulletins/letters and has reviewed the design of the ABWR for potential weaknesses in coping with the bulletin's concerns. GEH has determined that the ABWR design is more resistant to these problemssatisfactorily accommodates suppression pool debris for a number of reasons as discussed in the following.:

The ultimate concern raised by the Perry incident was the deleterious effect of debris in the suppression pool and how it could impact the ability to draw water from the suppression pool during an accident. To address this concern, Tthe ABWR design has committed to following the guidance provided in Regulatory Guide 1.82 as well as NEDO-32686-A (Utility Resolution Guide for ECCS Suction Strainer Blockage), and additional guidance as described below.

The ABWR is designed to inhibit debris generated during a LOCA from preventing operation of the Residual Heat Removal (RHR), Reactor Core Isolation Cooling (RCIC) and High Pressure Core Flooder (HPCF) systems.

6C.2 ABWR Mitigating Features

The ABWR has substantially reduced the amount of piping in the drywell relative to earlier designs and consequently the quantity of insulation required. Furthermore, there is no equipment in the wetwell spaces that requires insulation or other fibrous materials. The ABWR design conforms with the guidance provided by the NRC for maintaining the ability for long- term recirculation cooling of the reactor and containment following a LOCA.

The Perry incident was not the result of a LOCA but rather debris entering the Suppression Pool during normal operation. The arrangement of the drywell and wetwell/wetwell airspace on a Mark III containment (Perry) is significantly different from that utilized in the ABWR design. In the Mark III containment, the areas above the suppression pool water surface (wetwell airspace) are substantially covered by grating with significant quantities of equipment installed in these areas. Access to the wetwell airspace (containment) of a Mark III is allowed during power operations. In contrast, on the ABWR the only connections to the suppression pool are the 10 drywell connecting vents (DCVs), and access to the wetwell or drywell during power operations is prohibited. The DCVs will have horizontal steel plates located above the openings that will prevent any material falling in the drywell from directly entering the

vertical leg of the DCVs. This arrangement is similar to that used with the Mark II connecting vent pipes. Vertically oriented trash rack construction will be installed around the periphery of the horizontal steel plate to intercept debris. The trash rack design shall allow for adequate flow from the drywell to wetwell. In order for debris to enter the DCV it would have to travel horizontally through the trash rack prior to falling into the vertical leg of the connecting vents. Thus the ABWR is resistant to the transport of debris from the drywell to the wetwell.

In the Perry incident, the insulation material acted as a ~~sepia~~ septa to filter suspended solids from the suppression pool water. The Mark I, II, and III containments have all used carbon steel in their suppression pool liners. This results in the buildup of corrosion products in the suppression pool which settle out at the bottom of the pool until they are stirred up and re-suspended in the water following some event (SRV lifting). In contrast, the ABWR liner of the suppression pool is fabricated from stainless steel which significantly lowers the amount of corrosion products which can accumulate at the bottom of the pool.

A further mitigating feature for the ABWR is that the insulation installed on the ASME Section III, Class 1 piping greater than 80 mm in the drywell, i.e., the large bore piping, is reflective metal type (RMI). Use of RMI minimizes the fibrous insulation source term from the upper drywell used in the suction strainer design. This use of RMI is a significant factor in design that reduces the potential suction strainer debris load and further reduces the potential for suction strainer clogging.

Since the debris in the Perry incident was created by roughing filters on the containment cooling units a comparison of the key design features of the ABWR is necessary. In the Mark III design more than 1/2 of the containment cooling units are effectively located in the wetwell airspace. For the ABWR there are no cooling fan units in the wetwell air space. Furthermore the design of the ABWR Drywell Cooling Systems does not utilize roughing filters on the intake of the containment cooling units during plant operation. ~~.~~

In the event ~~that small quantities of~~ debris enters the suppression pool and does not settle on the pool bottom, the Suppression Pool Cleanup System (SPCU) will remove the suspended debris during normal plant and SPCU operation. The SPCU is described in Section 9.5.9 and shown in Figure 9.5-1. The SPCU is designed to provide a continuous cleanup flow of 250 m3/h. This flow rate is sufficiently large to effectively maintain the suppression pool water at the required purity. The SPCU system is intended for continuous operation and the suction pressure of the pump is monitored and ~~provides~~ an alarm is provided on low pressure. Early indication of any deterioration of the suppression pool water quality will be provided if significant quantities of debris were to enter the suppression pool and cause the strainer to become plugged resulting in a low suction pressure alarm.

~~The suction strainers at Perry did not meet the current regulatory requirements. 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.~~ The ABWR design also has additional features not utilized in earlier designs that could be used in the highly improbable event that all suppression pool suction strainers were to become plugged. The alternate ~~AC (~~Alternating Current~~)~~ independent water addition (ACIWA) mode of RHR allows water from the Fire Protection System to be pumped to the vessel and sprayed in the wetwell and drywell from diverse water sources to maintain cooling of the fuel and containment. The wetwell can also

be vented at low pressures to assist in cooling the containment.

6C.3 Design Considerations

6C.3.1 RG 1.82 Improvement

All ECCS strainers will at a minimum be sized to conform with the guidance provided in Reg Guide 1.82 for the most severe of all postulated breaks.

_The following clarifying assumptions will also be applied and will take precedence:

(1) The debris generation model will utilize right angle cones acting in both directionsshall be consistent with Methods 1, 2, or 3 from the zone of influence approach in Reference 6C-3. ;

(2) The amount of Of the debris insulation debris generated will be assumed to be 100% of the insulation in a distance of 3 L/D of the postulated break within the right angle cones including targeted insulation;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. This approach is conservative due to the ABWR containment improvements over the Mark III as discussed in Section 6C.2.

(3) All of the insulation debris generated will be assumed to be transported to the suppression pool;

(43) The debris in the suppression pool will be assumed to remain suspended until it is captured on the surface of a strainer.

Suction Strainer sizing is based on satisfying NPSH requirements at runout flow, plus margin, with the design basis debris in the suppression pool accumulated on the suction strainers.

The sizing of the suction strainers assumes that the insulation debris in the suppression pool is proportionally distributed to the pump suctions based on the flow rates of the operating systems at limiting runout conditions. The strainers assumed available for capturing insulation debris for the limiting design condition are two RHR suction strainers and a single HPCF or RCIC suction strainer.

6C.3.2 Chemical Effects

The chemical effects of the post-LOCA environment on debris shall be evaluated to assess the extent to which chemical reaction products contribute to blockage of the ECCS strainers. The evaluation shall be submitted by the COL Applicant and shall demonstrate that the effects of chemical reaction products from post-LOCA debris shall not prevent long-term cooling of the core (COL 6.12).

6C.3.3 Downstream Effects

The effects of debris passing through the strainers shall be evaluated for interactions with downstream components such as pumps, valves, and heat exchangers and also for the potential blockage of coolant flow at the entrance to the fuel assemblies. The evaluation shall be submitted by the COL Applicant and shall demonstrate that the effects of debris bypass of the strainer shall not prevent long-term cooling of the core (COL 6.12). The sizing of the RHR suction strainers will assume that the insulation debris in the suppression pool is evenly distributed to the 3 pump suctions. The strainer size will be determined based on this amount of insulation debris and then increased by a factor of 3. The flow rate used for calculating the strainer size will be the runout system flow rate.

The sizing of the RCIC and HPCF suction strainers will conform to the guidance of Reg Guide 1.82 and will assume that the insulation debris in the suppression pool is proportionally distributed to the pump suctions based on the flow rates of the systems at runout conditions. The strainers assumed available for capturing insulation debris will include 2 RHR suction strainers and a single HPCF or RCIC suction strainer.

6C.4 Discussion Summary

In summary, the ABWR design includes the necessary provisions to prevent debris from impairing the ability of the RCIC, HPCF, and RHR systems to perform their required post-accident functions. Specifically, the ABWR design does the following:

(1) (1) The design is resistant to the transport of debris to the suppression pool.

(2) (2) The suppression pool liner is stainless steel, which significantly reduces corrosion products.

(3)(2)

(3) The SPCU system will provide early indication of any potential problem.

(3) Plant Housekeeping and Foreign Material Exclusion (FME) procedures assure pool cleanliness prior to plant operation and over plant life such that no significant debris are present in the suppression pool

(4) Periodic SPCU operation maintains suppression pool cleanliness. Low SPCU pump suction pressure can provide early indication of debris present in the suppression pool and permit the plant operator to take appropriate corrective action.

(4) (4) The SPCU System operation will maintain suppression pool cleanliness.

(5) (5) The equipment installed in the drywell and wetwell minimize the potential for generation of debris.

(5)(6) The ECCS suction strainers meet the current regulatory requirements.

(6) The ECCS suction strainers meet the current regulatory requirements unlike the strainers at the incident plants.

(7) The RHR suction strainers will apply an additional factor of 3 design margins.

6C.5 COL License Information

6C.5.1 Debris Evaluation for ECCS Suction Strainer

An evaluation shall be submitted by the COL Applicant that demonstrates that chemical effects and the effect of debris bypass of the strainers does not prevent long-term cooling of the core (COL 6.12). The evaluation shall be based on the research and recommendations of the BWR Owner's Group GSI-191 committee.

6C.~~5~~ 6 ~~Strainer Sizing Analysis Summary~~References

6C-1 Debris Plugging of Emergency Core Cooling Suction Strainers, USNRC Bulletin No. 93-02, May 11, 1993.

6C-2 Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant Accident, USNRC Reg. Guide 1.82 Rev. 3.

6C-3 Utility Resolution Guidance for ECCS Suction Strainer Blockage, NEDO-32686-A, October, 1998.

A preliminary analysis was performed to assure that the above requirements could be satisfied using strainers compatible with the suppression pool design as shown by Figure 1.2-13i. The following summarizes the results, which indicate strainer sizes that are acceptable within the suppression pool design constraints.

Each loop of an ECCS system has a single suppression pool suction strainer configured in a T-shape with a screen region at the two ends of the T cross member. Analysis determined the area of each screen region. Thus, RHR with three loops has six screen regions. The HPCF with two loops has four screen regions, and the RCIC has two screen regions. The characteristic dimension given for the screens in the results below indicates a surface area consisting of a circle with a diameter of the dimension plus a cylinder with a diameter and length of the dimension.

By the requirements above, all of the debris deposits on the strainers. The distribution of debris volume to the strainer regions was determined as a fraction of the loop flow splits based on runout flow. Debris on the screen creates a pressure drop as predicted by NUREG-0897, which is referenced by R.G. 1.82. The equation for NUKON™ insulation on page 3-59 of NUREG-0897 was used for this analysis. The NUKON™ debris created pressure drop equation is a function of the thickness of debris on the screen (which is a function of debris volume), the velocity of fluid passing through the screen (runout flow used), and the screen area. The debris created pressure drop was applied in an equation as follows; the static head at the pump inlet is equal to the hydraulic losses through the pipe and fittings, plus the pressure drop through the debris on the strainers, plus the hydraulic loss through the unplugged strainer, plus a margin equal to approximately 10% of the static head at the pump inlet, and plus the required NPSH. The static head takes into account the suppression pool water level determined by the draw-down calculated as applicable for a main steam line break scenario. A summary provided in Table 6C-1, and a summary of the analysis results is provided in Table 6C-2.

By making realistic assumptions, the following additional conservatisms are likely to occur, but they were not applied in the analysis. No credit in water inventory was taken for water additions from feedwater flow or flow from the condensate storage tank as injected by RCIC or HPCF. Also, for the long term cooling condition, when suppression pool cooling is used instead of the low pressure flooder mode (LPFL), the RHR flow rate decreases from runout (1130 m^3/h) to rated flow (954 m^3/h), which reduces the pressure drop across the debris.

Table 6C-1 Debris Analysis Input Parameters

Estimated debris created by a main steam line break	2.6 m^3
RHR runout flow (Figure 5.4-11, note 13)	1130 m^3/h
HPCF runout flow (Table 6.3-8)	890 m^3/h
RCIC controlled constant flow (Table 5.4-2)	182 m^3/h
Debris on RHR screen region, 3 RHR loops operating	0.434 m^3
Debris on HPCF screen region	0.369 m^3
Debris on RCIC screen region	0.097 m^3
RHR required NPSH (Table 6.3-9)	2.4 m
HPCF required NPSH (Table 6.3-8)	2.2 m
RCIC required NPSH (Table 5.4-2)	7.3 m
RHR pipe, fittings and unplugged strainer losses*	0.60 m
HPCF pipe, fittings and unplugged strainer losses*	0.51 m
RCIC pipe, fittings and unplugged strainer losses*	0.39 m
Suppression pool static head above pump suction	5.05 m

* Calculated hydraulic losses

Table 6C-2 Results of Analysis

RHR screen region area/characteristic dimension	5.66 m^2/1.20 m
HPCF screen region area/characteristic dimension	1.46 m^2/0.61 m
RCIC screen region area/characteristic dimension	0.27 m^2/0.26 m
Total ECCS screen region area	40.0 m^2