November 2, 2007

LICENSEE: MITSUBISHI HEAVY INDUSTRIES, LTD.

FACILITY: US-APWR STANDARD DESIGN PRE-APPLICATION REVIEW

SUBJECT: SUMMARY OF THE JULY 26, 2007, PUBLIC MEETING ON SEVERE ACCIDENT ANALYSIS METHODOLOGIES FOR THE US-APWR

On July 26, 2007, a Category 1 public meeting was held between the U.S. Nuclear Regulatory Commission (NRC) staff and representatives of Mitsubishi Heavy Industries (MHI), Ltd. at NRC Headquarters in Rockville, Maryland. The purpose of the meeting was to discuss severe accident methodology and the assumptions MHI used for the analyses. A list of meeting attendees is provided as Enclosure 1. MHI presented handouts that are shown in Enclosures 2 and 3 and can be accessed through the Agencywide Documents Access and Management System Accession Numbers ML07260694 and ML072840557, respectively.

MHI presented information on the severe accident analysis methodology used on the US-APWR design and MHI's approach to evaluate the effectiveness of the mitigation features.

Severe accidents are a class of accidents beyond the design basis which result in core damage and may occur if plant conditions exceed design basis limits. MHI stated that it will demonstrate the US-APWR's ability to mitigate severe accident consequences by complying with NRC regulations, particularly Three Mile Island requirements of 10 CFR 50.34(f), by developing a Probabilistic Risk Assessment and by demonstrating technical resolution of applicable unresolved safety issues and generic safety issues discussed in NUREG-0933. Due to the similarity between the US-APWR and existing pressurized-water reactor (PWR) plants, in some cases MHI was able to apply current severe accident experimental databases and employ previously tested analytical methods.

MHI identified eight (8) severe accident issues: hydrogen mixing and combustion, core debris coolability, steam explosion (in- and ex- vessel), high pressure melt ejection and direct containment heating, temperature induced steam generator tube rupture, molten core concrete interaction, long-term containment overpressure, and equipment survivability.

MHI discussed their analysis of the hydrogen mixing and combustion. The analysis was done to demonstrate that the containment ensures a mixed atmosphere, the distributed hydrogen concentration will remain less than 10% and the containment integrity is maintained when the igniters are functional, and that the containment integrity is maintained assuming an Adiabatic Isochoric Complete Combustion of hydrogen. MHI explained that MAAP and GOTHIC models were used to evaluate the hydrogen release rate and the effectiveness of the igniters and atmosphere mixers. At this point, the NRC staff asked why MAAP was needed if the amount of H_2 could be calculated based on 100% zirconium reaction and why both MAAP and GOTHIC models needed to be used. MHI explained that MAAP was used to get a conservative hydrogen flow rate estimate for 100% clad failure, which was then applied as a boundary condition to the GOTHIC model. The modeling showed that local hydrogen concentrations would remain below 10% during severe accidents. MHI also stated that the containment ultimate structural capability was evaluated in accordance with Section 3 of the American Society of Mechanical Engineers (ASME) Code to show its ability to withstand the pressure rise associated with hydrogen control from the igniters, as well as AICC.

Next, MHI discussed their analysis of the cooling of the core debris when the reactor cavity is flooded. This analysis will be done using a MAAP model whose assumption of water ingression into the melt is supported by COTELS and OECD MCCI experiments. The modeling assumes two characteristic scenarios for debris cooling; the debris drops into a water pool, or the water is injected onto molten debris on the cavity floor. Inherent uncertainties will also be considered, such as the amount of water ingression into the debris bed and the effectiveness of heat transfer. NRC emphasized the importance of providing a list of model parameters and ranges. When there are variations to parameter ranges, there will be a reference available with experimental data to make sure the variations are within range.

The third severe accident analysis that MHI discussed was in- and ex-Vessel steam explosions. For in-vessel steam explosions MHI examined the applicability of existing PWR studies and found that current studies apply to the US-APWR and that in-vessel steam explosion is unlikely and has a minimal importance with regard to risk. For ex-vessel steam explosions, MHI will estimate the pressure load and evaluate the containment's ability to withstand the increase. MAAP calculations will be used to set the initial conditions for a TEXAS-V analysis which will predict the pressure load. The structural capability of the containment will then be evaluated with these loads using LS-DYNA. At this point, the staff commented that the approach appears sound, but MHI must be careful to be thorough when creating and running their structural analysis model.

MHI then discussed analysis goals they had established to adequately address severe accidents related to High Pressure Melt Ejection (HPME) and Direct Containment Heating (DCE). These included demonstrating the adequacy of the Reactor Coolant System (RCS) depressurization valve, investigating the ability of a debris trap to limit the amount of core debris dispersed to the atmosphere, and demonstrating the containment structure has sufficient capability to withstand the pressure rise. MHI explained that the ability of the RCS depressurization valve to prevent HPME will be evaluated using a MAAP model. The amount of core debris will be estimated by examining existing studies and their applicability to the US-APWR. The structural capability will be investigated by conservatively assuming the amount of core debris dispersion and then using a two-cell equilibrium model to evaluate the pressure rise due to DCE.

The fifth severe accident analysis method discussed by MHI was Temperature Induced Steam Generator Tube Rupture (TI-SGTR). MHI explained the goal of the analysis is to demonstrate the capacity of the RCS depressurization valve is sufficient to ensure that the potential of TI-SGTR is acceptably low. MHI explained that MAAP will be used to analyze high pressure scenarios and the ability of the depressurization valve to operate sufficiently in these conditions. Existing related studies will also be reviewed to gauge their applicability to the US-APWR. NRC suggested running two (2) MAAP levels (1) a high day high steam generator pressure and, (2) a high day low steam generator pressure.

The sixth severe accident analysis discussed by MHI was Molten Core Concrete Interaction (MCCI). The goals of this analysis are to demonstrate that containment integrity will remain during the MCCI related pressure rise beyond 24 hours after the initial onset of core damage, and to show that basemat melt-through will not occur within 24 hours. MHI explained that the analysis utilizes MAAP to investigate characteristic accident scenarios, including no water in the reactor cavity, to see if the containment structural capability remains in place after 24 hours.

The effect on MCCI, and the resulting erosion and gas generation rates, due to differences in material properties from the use of different common sands will also be reviewed. NRC said to consider sensitivity studies if the MAAP downward and sideward ablation rates are the same.

The seventh severe accident analysis discussed was long-term containment overpressure. The goal of this analysis is to show the effectiveness of diverse mitigation features and the ability of containment to withstand pressurization for more than 24 hours following core damage. Once again MAAP will be used to evaluate the effectiveness of the mitigation features, including containment spray, alternative containment cooling by recirculation unit, and firewater injection to spray header. The containment's structural capability will also be examined. At this point, the staff reminded MHI to model the containment's response assuming none of the mitigation features are functional.

The eighth and final severe accident analysis discussed by MHI was equipment survivability. The goal of this analysis is to demonstrate equipment survivability of systems and components to maintain safe shutdown under condition created by hydrogen burning, per 10 CFR 50.44(c)(3). MHI explained that the necessary systems and components will be identified during the Design Certification (DC) stage, while a complete analysis will be provided as part of a Combined License (COL). Various accident scenarios will be analyzed using MAAP, while GOTHIC will be used to analyze environmental conditions. For the DC, the availability of systems and components under the calculated environmental conditions will be investigated. At this point, the staff asked if a PRA would be completed for the DC. MHI responded that a PRA for major components could be included in the DC, but a complete, plant-specific PRA would be incorporated into the COL.

At the conclusion of the meeting, NRC staff stated the overall severe accident analysis approach is sound. Members of the public were in attendance. A Public Meeting Feedback form was received. The feedback was positive and the attendee felt that the staff provided clear responses to MHI questions and clearly outlined the NRC expectations. The feedback has been entered into the NRC Public Meeting Feedback System. Please direct any inquiries to me at 301-415-1626, or bcl1@nrc.gov

/RA/

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Division of New Reactor Licensing
Office of New Reactors

Project No. 751

Enclosures:
1. List of Attendees
2. Mitsubishi Handout - US-APWR
   8th Pre-Application Review Meeting -
   Severe Accident Analysis Methodology
3. Mitsubishi Handout - US-APWR
   8th Pre-Application Review Meeting -
   Design Features for SA Mitigation

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The eighth and final SA analysis discussed by MHI was equipment survivability. The goal of this analysis is to demonstrate equipment survivability of systems and components to maintain safe shutdown under condition created by hydrogen burning, per 10 CFR 50.44(c)(3). MHI explained that the necessary systems and components will be identified during the Design Certification (DC) stage, while a complete analysis will be provided as part of a Combined License (COL). Various accident scenarios will be analyzed using MAAP, while GOTHIC will be used to analyze environmental conditions. For the DC, the availability of systems and components under the calculated environmental conditions will be investigated. At this point the staff asked if a PRA would be completed for the DC. MHI responded that a PRA for major components could be included in the DC, but a complete, plant-specific PRA would be incorporated into the COL.

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Meeting Summary for July 26, 2007 Public Meeting with Mitsubishi Heavy Industries by Bryce Lehman dated November, 2007

SUBJECT: SUMMARY OF THE JULY 26, 2007, PUBLIC MEETING ON SEVERE ACCIDENTANALYSIS METHODOLOGIES FOR THE US-APWR

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Public Meeting to Discuss

Severe Accident Analysis Methodology Topical Reports

July 26, 2007

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Hugh Thompson	Talisman - International
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Alan Levin	AREVA
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Theresa Clark	NRC
Don Dube	NRC
Edward Fuller	NRC
Mark Melnicoff	NRC
Lynn Mrowca	NRC
Hanh Phan	NRC
Nick Saltos	NRC

Enclosure 1

Enclosure 2

Mitsubishi Handout - US-APWR
8th Pre-Application Review Meeting-
Severe Accident Analysis Methodology

(ML072680694)

Enclosure 3

Mitsubishi Handout - US-APWR
8th Pre-Application Review Meeting -
Design Features for SA Mitigation

(ML072840557)

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