

March 28, 2011

**DESIGN CERTIFICATION SECTION 6.2.2 AND SECTION 6.3  
NET POSITIVE SUCTION HEAD AUDIT PLAN**

**April 7, 2011**

**US-APWR DESIGN CERTIFICATION  
Mitsubishi Heavy Industries, Ltd.  
Docket No. 52-021**

Location: Mitsubishi Nuclear Energy Systems, Inc.  
1001 19th Street North, 7<sup>th</sup> Floor  
Arlington, VA 22209

Purpose:

The purpose of this audit is to review, verify and identify information and documentation that is related to net positive suction head (NPSH) calculations for containment spray/residual heat removal (CS/RHR) and safety injection (SI) pumps. The audit will review and evaluate supporting NPSH calculations for the Mitsubishi Heavy Industries, Ltd. (MHI) Design Certification Section 6.2.2, "Containment Heat Removal Systems," Table 6.2.2-1 and Section 6.3, "Emergency Core Cooling Systems (ECCS)," Table 6.3-5, as well as related Technical Report MUAP-08001-P, Revision 3, "US-APWR Sump Strainer Performance," Table 3-11, Table F-2 and Table F-3.

Background:

On March 8, 2010, the U.S. Nuclear Regulatory Commission (NRC) staff traveled to the Mitsubishi Nuclear Energy Systems, Inc. (MNES) office in Arlington, Virginia, and conducted an audit of the NPSH calculations for the ECCS pumps. The NRC staff reviewed the documentation associated with the NPSH calculations provided by MHI and found, in general, that the calculation method used in the NPSH calculations was consistent with guidance and typical practices, except as noted in the discussion on Containment Accident Pressure (CAP), and included conservative assumptions to maximize the head loss. As a result, the NRC staff could not complete its review and make a safety finding on the available NPSH calculation.

Regulatory Audit Basis:

General Design Criteria (GDC) 38 of Title 10 of the *Code of Federal Regulations* (10 CFR), Part 50, Appendix A, "Containment Heat Removal," requires that the containment heat removal system accomplishes its safety function to rapidly reduce containment pressure and temperature following a loss-of-coolant accident (LOCA) and to maintain these indicators at acceptably low levels without pump damage caused by cavitation. A supporting analysis should be presented in sufficient detail to permit the NRC staff to determine the adequacy of the analysis.

This analysis should also demonstrate that the available NPSH is greater than or equal to the required NPSH. Regulatory Guide 1.82, "Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant Accident," Revision 3, describes methods acceptable to the NRC staff for evaluating the NPSH margin.

In accordance with 10 CFR 50.46(b)(5), the NRC staff reviews applications against the requirements for long-term cooling, including adequate NPSH margin in the presence of LOCA generated and latent debris.

To show compliance with GDC 35, "Emergency Core Cooling," MHI must show that the ECCS pumps will perform their intended functions during postulated accidents. The ECCS should be designed so that sufficient available NPSH is provided to the system pumps assuming the maximum expected temperature of the pumped fluid and no credit for containment pressurization during the accident.

Regulatory Audit Scope:

The audit scope will focus the review on MHI's NPSH related calculations for the ECCS pumps that detail the NPSH input values identified in Technical Report MUAP-08001-P, Revision 3, Table 3-11, "Upstream Effect Hold-Up Volumes" and Appendix-F, "Validity of Assumptions Regarding Containment Pressure." The NRC staff may also consider information previously reviewed during the March 8, 2010, Audit Report regarding NPSH (ML101540228). The NRC staff plans to review and discuss with MHI, the following items during the NPSH follow-up audit:

1. The calculations used to develop Table F-2, "LOCA Cases and Assumptions for Figure F-1 through F-4" and Table F-3, "LOCA Cases and Assumptions for Figure F-5 and Figure F-7" to include the following:
  - A. Intended biases selected to maximize refueling water storage pool (RWSP) liquid temperature and minimize containment pressure.
    - a. Sensitivity of containment response to variations in modeling assumptions such as liquid volume, containment volume, spray initiation, heat transfer surfaces, heat transfer coefficients, spray droplet size, etc.
  - B. Applicability of the methodology used in the GOTHIC code to support the CAP analysis.
  - C. Sensitivity studies performed to determine conservativeness of CAP analysis.
  - D. Mass and Energy inputs.
    - a. Assumptions in the Mass and Energy calculations intended to maximize the RWSP liquid temperature.
  - E. Calculation uncertainty.

2. The calculation for the minimum water level in the Refueling Water Storage Pit (water hold-up and/or upstream effects analysis.)
3. Description of how the required NPSH uncertainties will be addressed.

Additionally, the audit will include the review of Requests for Additional Information (RAIs) and responses, if available, that are related to the NPSH assumptions and calculations.

Information and Other Material on Hand for the Audit:

The NRC staff requests that all NPSH calculations and internal documentation listed in the references below be made available during the audit.

Audit Team:

Clinton Ashley - Lead Auditor  
Jeffrey Schmidt - Lead Auditor  
Andrzej Drozd - Team Member  
Eric Miller - Team Member  
Ed Throm - Team Member  
Ruth Reyes - Project Manager

Logistics:

The audit will be conducted at the MNES location. The audit is scheduled to begin at 9:00 a.m. Participating individuals will meet at the audit location. Appropriate handling and protection of proprietary information shall be acknowledged and observed throughout the audit.

Special Requests:

None.

Deliverables:

An audit report will be generated after completion of the audit. The audit outcome will be used to identify any additional information to be submitted for making regulatory decisions. The audit will assist the NRC staff in the preparation and issuance of further RAIs for the licensing review of the United States - Advanced Pressurized Water Reactor (US-APWR) Design Certification Application, Section 6.2.2 and Section 6.3.

References:

1. US-APWR, Design Control Document, Revision 2.
2. Technical Report MUAP-08001-P, Revision 3, "US-APWR Sump Strainer Performance."
3. NPSH Calculations for the SI and CS/RHR Pumps.
4. Calculation 4BS-UAP-100005, "NPSH Available for the SI Pumps and CS/RHR Pumps."
5. Calculation 4BS-UAP-100006, "Pressure Loss of Suction Piping for SI Pumps and CS/RHR Pumps."
6. Calculation 4CS-UAP-2007012, "Water Volume of RWSP, Holdup Water and Refueling Cavity for Safety Analysis."

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References:

1. US-APWR, Design Control Document, Revision 2.
2. Technical Report MUAP-08001-P, Revision 3, "US-APWR Sump Strainer Performance."
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6. Calculation 4CS-UAP-2007012, "Water Volume of RWSP, Holdup Water and Refueling Cavity for Safety Analysis."

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