PWR-GALE COMPUTER CODE AUDIT REPORT

NRC Audit Staff: Ngola Otto, Project Manager, NRO/DNRL/NMIP
Richard Clement, NRO/DCIP/CHPB

1.0 SUMMARY

Mitsubishi Heavy Industries Ltd. (MHI) submitted to the U.S. Nuclear Regulatory Commission (NRC), Design Control Document (DCD) Revisions 0, 1, and 2 for its United States - Advanced Pressurized Water Reactor (US-APWR) application in December 2007, August 2008, and October 2009, respectively. After conducting a review of the information and responses to Requests for Additional Information (RAIs) associated with DCD Tier 2, Chapter 11, "Radioactive Waste Management" and interfacing DCD Tiers 1 and 2, the NRC staff concluded that additional information was needed to make a determination that the applicant meets the applicable regulatory requirements to comply with Title 10 of the *Code of Federal Regulations* (10 CFR) Parts 20, 50, and 52; and 40 CFR Part 190.

An audit was conducted by the NRC staff at the MHI, Arlington, Virginia office during July 28 - 29, 2010. The focus of the audit was to review and evaluate supporting MHI PWR-GALE computer code calculations for DCD Tier 2, Chapter 11, "Radioactive Waste Management," Section 11.2, "Liquid Waste Management System" (LWMS) and Section 11.3, "Gaseous Waste Management System" (GWMS). The NRC staff also focused on the waste gas surge tank leak and charcoal bed leak analyses in DCD, Tier 2, Section 11.3.

The purpose of this audit was to: 1) review and verify information and documentation for closure of the RAIs related to the MHI PWR-GALE computer code calculations of annual liquid and gaseous effluent releases for normal and maximum releases, the charcoal bed leak analysis, and the waste gas surge tank leak analysis; 2) to discuss apparent inconsistencies in the DCD, Tier 2 relevant to Chapter 11 and the new approach on the liquid tank failure analysis; and 3) to resolve other opens items in the DCD, Tier 2, Chapter 11 Safety Evaluation (SE).

Prior to the audit, MHI submitted to the NRC, under 10 CFR 2.390, a compact disk (CD) of its proprietary version, MHI PWR-GALE computer code, of the NRC PWR-GALE (GALE86) code which included a relative path batch file to execute the code. The NRC staff previously requested this information through RAIs, but was not able to execute the MHI PWR-GALE computer code without modifying the batch file. Using the supplied CD, the NRC staff executed the MHI PWR-GALE computer code used to calculate annual liquid and gaseous effluent releases for normal releases and anticipated operational occurrences. These effluent releases are used as inputs to calculate site-specific effluent doses in the Comanche Peak Nuclear Power Plant (CPNPP), Units 3 and 4, and North Anna, Unit 3, Environmental Impact Statements and Combined Operating License (COL) Final Safety Analysis Reports (FSARs).

During the audit, MHI presented information to support the basis of several key input design values used in the MHI PWR-GALE computer code calculations for demonstration of compliance with the regulatory requirements. The NRC staff discussed with MHI the waste gas surge tank leak and charcoal bed leak analyses and the development of a technical report for the MHI PWR-GALE computer code; apparent consistencies with information presented in the DCD, Tier 2, Chapter 11 and interfacing DCD, Tiers 1 and 2 sections involving GWMS mobile or

temporary equipment, NRC Inspection and Enforcement (IE) Bulletin 80-10, and GWMS discharge isolation valves; the fire hazard analysis associated with an external fire involving the charcoal delay beds; and the Auxiliary Building (A/B) ventilation system for gaseous effluent discharges to the environment via the plant vent stack. The NRC staff also discussed with MHI, the applicability of 10 CFR 52.47a(1) and a(2) to the liquid tank failure analysis in DCD, Tier 2, Section 11.2.3.2 and the COL Application evaluation of the liquid tank failure analysis satisfied through COL Information Item 11.2(3).

2.0 BASIS

- 10 CFR, Part 20, “Standards for Protection Against Radiation”
- NUREG-0800, “Standard Review Plan,” Chapter 11, “Radioactive Waste Management”
- 10 CFR Part 50, Appendix A, General Design Criterion (GDC) 60, “Control of Releases of Radioactive Materials to the Environment”
- 10 CFR Part 50, Appendix A, GDC 64, “Monitoring Radioactivity Releases”
- 10 CFR Part 50, Appendix I, “Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion “As Low As Is Reasonably Achievable” for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents”
- 10 CFR 50.34a, “Design Objectives for Equipment to Control Releases of Radioactive Material in Effluents - Nuclear Power Reactors”
- 10 CFR 50.36, “Technical Specifications”
- 10 CFR 50.9, “Completeness and Accuracy of Information”
- 10 CFR Part 52, “Licenses, Certifications, and Approvals for Nuclear Power Plants”
- 40 CFR Part 190, “Environmental Radiation Protection Standards for Nuclear Power Operations”
- RG 1.109, “Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I”
- RG 1.112, “Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Light-Water-Cooled Power Reactors”
- RG 1.143, “Design Guidance for Radioactive Waste Management Systems, Structures and Components Installed in Light-Water-Cooled Nuclear Power Plants”
- RG 1.206, “Combined License Applications for Nuclear Power Plants (LWR Edition)”
- NUREG-0017, “Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors (PWRs) (PWR-GALE Code)”

- NUREG-0800, “Standard Review Plan,” Chapter 11, “Radioactive Waste Management”
- BTP 11-5, “Postulated Radioactive Releases Due to a Waste Gas System Leak or Failure”
- BTP 11-6, “Postulated Radioactive Releases due to Liquid-Containing Tank Failures”
- NUREG/CR-4653, “GASPAR II - Technical Reference and User Guide”
- NUREG/CR-4013, “LADTAP II - Technical Reference and User Guide”
- ANSI/ANS-18.1-1999, “Radioactive Source Term for Normal Operation of Light Water Reactors”
- 10 CFR Part 50, Appendix A, GDC 3, “Fire Protection”
- RG 1.189, “Fire Protection for Nuclear Power Plants,” Revision 1

3.0 OBSERVATIONS AND RESULTS

3.1 MHI PWR-GALE Computer Code

MHI presented the NRC staff with information (some with English translation) to support the basis of several key input design values used in the MHI PWR-GALE computer code which included the reactor coolant system component reactor coolant inventory for US-APWR systems, a key factor in the calculation of gases leakage rate; the cation demineralizer water flow rate; the liquid mass in each steam generator; and the steam generator blowdown rate and blowdown treatment method applied in the MHI PWR-GALE computer code. Based on the information provided and discussion with MHI, the NRC staff found no issues with the basis on the input design values.

MHI PWR-GALE computer code calculations of liquid and gaseous effluent releases, LADTAP II code calculations of liquid effluent doses, GASPAR II code calculations of gaseous effluent doses, waste gas surge tank leak analysis, and charcoal bed leak analysis were made available at the audit.

The applicant's modifications to the NRC PWR-GALE (GALE86) code which are incorporated into the recompiled MHI PWR-GALE computer code include the noble gases leakage rate reduction from 3.0 percent per day to 0.02 percent per day, the updated American National Standards Institute (ANSI)/American Nuclear Society (ANS)-N18.1-1999 primary coolant concentrations, and the addition of Ba-137M. In V2.1 to the MHI PWR-GALE computer code, the applicant addressed the correction for the Y-93 (water) secondary coolant concentration reported in the Errata sheet for ANSI/ANS-N18.1-1999. The NRC staff discussed with MHI, that the DCD should reference the MHI PWR-GALE computer code because it was used in place of the GALE86 code to calculate effluent releases and subsequent doses in the US-APWR design.

The NRC staff and MHI discussed the development of a technical report for the MHI PWR-GALE computer code to describe modifications to the GALE86 code, calculation packages, and the Quality Assurance (QA) documentation on the validation and installation plan for the MHI PWR-GALE computer code. MHI agreed to provide the technical report at a later date with the information discussed.

3.2 Inconsistencies in DCD, Tier 2, Chapter 11 and Interfacing DCD, Tiers 1 and 2 sections

The NRC staff discussed with MHI, apparent inconsistencies in DCD, Tier 2, Chapter 11 and information presented in interfacing DCD, Tiers 1 and 2 sections as follows:

DCD Tier 2, Section 11.3.1.6, “Mobile or Temporary Equipment” was revised to state that the GWMS does not include the use of mobile or temporary equipment, but DCD, Tier 2, Section 14.3.7, “ITAAC for Plant Systems” describes the Inspections, Tests, Analysis, and Acceptance Criteria (ITAAC) for verifying the performance of the GWMS (as permanently installed systems or in combination with mobile processing equipment).

DCD, Tier 2, Section 11.3.1.2, “Design Criterion” describes interconnections between the GWMS and other plant systems to preclude contamination of non-radioactive systems and minimize uncontrolled and unmonitored releases of radiation to the environment, but does not fully identify compliance with IE Bulletin 80-10 for the described GWMS design features. In accordance with the Standard Review Plan (SRP) and Regulatory Guide 1.206, acknowledgement of the IE Bulletin 80-10 should be addressed in DCD, Tier 2, Sections 11.2 through 11.5.

DCD, Tier 2, Section 11.3.4, “Ventilation System” describes a discharge isolation valve located downstream of the discharge radiation monitor which closes on a low ventilation system exhaust flow rate to minimize the release of treated gaseous waste and the accumulation of hydrogen in the vent stack. DCD, Section 11.3.2.1.4, “Hydrogen/Oxygen Analyzers” describes isolation of gas sources to the charcoal delay bed by closing this valve when a high-high alarm occurs. DCD, Tier 2, Section 11.3.2, “System Description” describes the discharge valves as remaining open when the radiation setpoint is not exceeded and closure when there is a lack of ventilation flow in the vent stack. DCD, Tier 1, Section 2.7.4.2.1, “Design Description” verifies automatic closure of the GWMS effluent discharge valves in the ITAAC. Although the GWMS discharge isolation valves are not described in DCD, Tiers 1 and 2, information as serving a safety function, the LWMS discharge isolation values installed on the sole discharge line to monitor and control liquid effluent releases to the environment are described in DCD, Tiers 1 and 2 information as serving a safety function.

3.3 Fire Hazard Analysis for Charcoal Delay Beds in the GWMS

The NRC staff discussed with MHI, whether the fire hazard analysis in DCD, Tier 2, Appendix 9A, “Fire Hazard Analysis” evaluated the potential impact due to an external fire involving the charcoal delay beds in the GWMS located in the A/B. The GWMS design described in DCD, Tier 2, Table 11.3-2, “GWMS Major Equipment Design Information (Sheets 2 of 2)” specifies four charcoal bed columns each containing 60 ft^3 of charcoal (240 ft^3 total volume) housed in stainless steel. Although DCD, Tier 2, Appendix 9A.3.129 FA4-101, “Auxiliary Building” describes the potential for a radioactive materials release resulting from a fire within the radwaste areas, DCD, Tier 2, Section 11.3 and Table 11.3-3, “Equipment Malfunction Analysis”

and DCD, Appendix 9A.3, “Fire Hazards Analysis Results” does not appear to indicate that a fire hazard analysis for an external fire involving the charcoal delay beds in the GWMS is evaluated.

3.4 A/B Ventilation System

The NRC staff discussed with MHI whether the A/B ventilation system for gaseous effluent discharges to the environment via the plant vent stack should contain high-efficiency particulate air (HEPA) and carbon filtration. DCD, Tier 2, Section 11.3.3.1, presents the detailed design information for the vent stack on the height of release, stack diameter, effluent temperature and flow rate, effluent exit velocity, and the size and shape of flow orifices satisfied through COL Information Item 11.3(3). The vent stack runs alongside containment and is the only release point above the top of containment for the GWMS and heating, ventilation, and air conditioning (HVAC) systems associated with the Reactor Building, A/B, and Access Building. DCD, Tier 2, Figures 9.4.3-1, “Auxiliary Building HVAC System Flow Diagram” and 9.4.5-1, “Annulus Emergency Exhaust System Flow Diagram” do not show the presence of HEPA and carbon filtration in the A/B ventilation system for gaseous effluent discharges to the environment via the plant vent stack.

3.5 Liquid Tank Failure Analysis

The NRC staff discussed with MHI, the new approach on the liquid tank failure analysis using the RATAF code in DCD, Tier 2, Section 11.2.3.2, “Radioactive Effluent Releases due to Liquid Containing Tank Failures” which impacts DCD, Tier 2, Section 2.4.13, “Accident Releases of Radioactive Liquid Effluent in Ground and Surface Waters” and the corresponding sections in the CPNPP, Unit 3 and 4, and North Anna, Unit 3, COL FSARs. The RATAF code, based on GALE (1974) and 0.01 failed fuel fraction, is described in NUREG-0133 (referenced in SRP Section 11.2 and Branch Technical Position (BTP) 11-6) was developed by the NRC to specifically address the radiological consequences of a failed liquid tank in the radwaste system. MHI will revisit the RATAF code to calculate the liquid tank inventory and radionuclide distribution for the postulated failed tank in accordance with the NRC guidance. Based on the applicant’s analysis, the boric acid tank will be selected as the liquid tank which contains the highest radionuclide concentrations in DCD, Tier 2, Section 11.2.3.2. Input design values specific to the RATAF code (in addition to those shared in the MHI PWR-GALE computer code) will be used to calculate tank inventory and radionuclide distribution with the RATAF code for the application in COL Information Item 11.2(3). The NRC staff discussed with MHI, the acknowledgment of potential minor concerns associated with the RATAF code such as an earlier ANSI source term and effluent concentration limits (ECLs) which should be compared to updated ECLs in 10 CFR Part 20, Appendix B, Tables 1 and 2 for the sum-of-ratios calculation in the COLA.

4.0 CONCLUSION

Based on audit discussions, MHI will submit for the NRC staff review, its new approach on the liquid tank analysis using the RATAF code, the RATAF code input/output files and calculation packages, the proposed revision to DCD, Tier 2, Section 11.2.3.2, with an accompanying revised RATAF summary data table identifying the failed tank inventories and radionuclide distributions, and the basis for the RATAF code input design values in accordance with guidance in SRP Sections 11.2 and 2.4.13, and BTP 11-6. The NRC staff did not find any issues with the applicant using the RATAF code to calculate the failed liquid tank failure

inventory and radionuclide concentrations. In regards to the liquid tank failure analysis, the NRC staff reiterated to MHI that the LWMS design must be bounded in the DCD for the COLA based on 10 CFR 52.47a (1) and a (2). The NRC staff communicated to MHI that RAIs will be developed and issued from the audit findings.

The requested information presented by MHI at the audit was necessary for the NRC staff in determining reasonable safety assurance of compliance with the regulatory requirements. This information includes the basis for key input design values used in the applicant's proprietary version, MHI PWR-GALE computer code, of the NRC PWR-GALE (GALE86) code; and the calculation packages for the MHI PWR-GALE computer code calculations of annual liquid and gaseous effluent releases (for normal and maximum releases), the LADTAP II code calculations of liquid effluent doses, the GASPAR II code calculations of gaseous effluent doses, the waste gas surge tank leak analysis, the charcoal bed leak analysis, and the RATAF code calculations of failed liquid tank radionuclide inventories and concentrations.

MHI will submit to the NRC, a technical report on the MHI PWR-GALE computer code describing modifications to the NRC PWR-GALE (GALE86) code, calculation packages, and QA documentation on the validation and installation plan for the MHI PWR-GALE computer code.

The NRC staff discussed with MHI, the apparent inconsistencies with information presented in DCD, Tier 2, Chapter 11 and interfacing DCD, Tiers 1 and 2 sections, and whether the fire hazard analysis in DCD, Tier 2, Appendix 9A evaluated the potential impact due to an external fire involving the charcoal delay beds in the GWMS. Further, the NRC staff discussed with MHI, whether the A/B ventilation system should contain HEPA and carbon filtration for gaseous effluent discharges to the environment via the plant vent stack. Therefore, the NRC staff issued RAI 624-4972, Question 11.02-33 and RAI 629-4973, Question 11.03-18 which will be evaluated in the DCD, Tier 2 Chapter 11 SE.