REQUEST FOR ADDITIONAL INFORMATION 427-2909 REVISION 1

7/30/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021
SRP Section: 12.02 - Radiation Sources
Application Section: 12.2

QUESTIONS for Health Physics Branch (CHPB)

12.02-17

The US-APWR FSAR Revision 1 Tier 2 Sections 2 “Radiation Sources” describes design features that provide the bases for the shielding design calculations and the airborne radioactivity concentrations that provides the bases for the ventilation system design.

Supplemental Question (SQ-1) derive from RAI 141-1735

RAI 141-1735 Question 12.02-6 requested additional information about the source term associated with In Core Instrument System (ICIS) and the Spent Fuel Pool and Refueling Pool water activity concentrations.

In the response the applicant indicated that:

1. MHI provided tables 12.2-70 and 12.2-71 for equipment material specifications and revised sections 12.2.1.2.3 and 12.2.1.2.5 to describe the method for determining activation of ICIS cables. This response appears to be inadequate and inconsistent with other information provided by MHI because:
   - Table 12.2-70 “Parameters and Assumptions for Calculating Spent Fuel Source Strength” notes that fuel enrichment is 4.55%, while US-APWR FSAR Tier 2 Table 4.2-1 “Fuel Assembly Design Specifications” list Fuel Enrichment as 5%.

     Provide a fuel enrichment source term for spent fuel that is consistent with other sections of the DCD or provide the justification for the use of a different fuel enrichment in this section.

   - As noted in US-APWR FSAT Tier 2 Section 7.7.1.5.2, the ICIS detectors are miniature fission detectors. Table 12.2-71 “Parameters and assumptions for Calculating Irradiated Incore Detector, Drive Cable and Flux Thimble Source Strength” does not show the source term and dose rates associated with these fission detectors.

     Describe the dose rates, and their bases, for the fission chambers of the In Core Instrument System neutron detectors, or provide the specific alternative approaches used and the associated justification.

References

1. "Request for Additional Information No. 141-1735 Revision 1, SRP Section: 12.02 - Radiation Sources, Application Section: 12.2,", Question No.: 12.02-6" dated January 9, 2009 CHPB Branch (ADAMS Accession No. ML090410551)

12.02-18

The US-APWR FSAR Revision 1 Tier 2 Sections 2 “Radiation Sources” describes design features that provide the bases for the shielding design calculations and the airborne radioactivity concentrations that provides the bases for the ventilation system design.

Supplemental Question (SQ-2) derive from RAI 142-1733

RAI 142-1733 Questions 12.02-8 and 12.02-9 requested additional information about the bases, models and assumptions supporting the dose rates indicated around the Boric Acid Evaporator (BAE) package, the associated pumps (Concentrates and Distillate), and the airborne activity concentrations associated with sludge removal from the BAE during maintenance, under the deign basis conditions of 1% defective fuel cladding.

In summary, the Applicant Response indicated that:

1. Based on other plant experience, actual doses from this equipment will be insignificant.

   This response is inconsistent with information provided by the Applicant in the US-APWR FSAR Tier 2 Section 12.2.1.1 “Sources for Full-Power Operation” which states that “The design basis for the shielding source terms for the fission products for full-power operation is cladding defects in the fuel rods producing 1% of the core thermal power”. The use of cladding defects for determining the shielding requirements is consistent with the Acceptance Criteria contained in SRP Section 12.2.

   Describe the source term used as the basis for determining the dose rates, shielding requirements, airborne activity concentration and ventilation system design parameters, and the resultant ORE dose reduction design features for normal operation and abnormal operating occurence (AOO), and provide the associated revisions to the FSAR, or provide the specific alternative approaches used and the associated justification.

2. The Applicant stated that filters and demineralizers in the feed stream will remove suspended activity, so no radioactivity deposits will remain in the boron recycle system.

The assumption that no activity would be present in the process fluid streams after the demineralizers and filters is inconsistent with the applicant response to RAI 168-1739 Question 12.02-14, which provided DF values for filters and demineralizers, and Average concentration factors for fluid that has passed through the BAE. Additionally, from NRC Staff OE with nuclear and non-nuclear evaporator systems, sludge and scale accumulate in the evaporator internals. EPRI report TR-1011728 “Radioactive Liquid Processing Guidelines” provides corroboration of the staff operating experience (OE). Since this material remains in the evaporator package following draining for maintenance, it is a significant source of internal and external exposure to maintenance personnel accessing the area around the BAE package. In some plants, due to these deposits, the BAE were posted as High Radiation Areas. At those plants, BAE input source terms were higher than realistically expected for current generation plants, but they were still significantly less than the US-APWR design basis source term, while filtration and purification of the BAE input stream was as good as or better than, currently proposed in the US-APWR.

Calculations performed by the staff, using the criteria described in NUREG-1400 “Air Sampling in the Workplace” Section 1 “Air Sampling Based on Potential Intakes and Concentrations” indicated the potential for maintenance related airborne activity concentrations exceeding an ALI, for distributed source activity 1/100th of that needed to cause a High Radiation Area due to activity deposited in the BAE.

Describe the source terms, their bases, and the resultant external exposure and airborne activity concentrations, associated with maintenance of internal and external components of the BAE package and the Boric Acid Evaporator Concentrates pump, under operation and maintenance associated with design bases cladding defects.

3. In the response to RAI 168-1739 Question 12.02-14, the Applicant provided Average concentration factors for fluid that has passed through the BAE. which appear to present non-conservative estimates of the amount of activity in the BAE and concentrates pump. The Applicant assumes a concentration factor of 35, based on increasing boron from 200 ppm to 7000 ppm. However from Question 168-1739 12.02-14 Table A, the volume of water processed by the BAE significantly exceeds the capacity of a Chemical and Volume Control System holdup tank (CVCS HUT), so at some point in time, the BAE will be operating with a feed stream boric acid concentration closer to 10 ppm. However, the activity concentration will not decrease like the boron concentration. In order to reach the target boric acid concentration of 7000 ppm, the concentration ratio will be closer to 700, not 35. In addition, insufficient information has been provided to allow the staff to determine if the BAE package operates with a constant concentration factor output, or a constant boron concentration output. This operational method is significant because the concentration factor in the BAE package may approach 1000 in some cases. In either case, higher fission product activity will be present

resulting in higher dose rates and contamination levels, in the BAE package and concentrates pump.

Describe the BAE package external exposure and airborne activity concentrations, and the associated bases, for internal and external maintenance of the BAE following processing a boric acid solution representative if End Of Core Life (~10 ppm) with design bases cladding defects.

4. The Applicant noted that the parameters of the Boric Acid Evaporator and Vent Condenser will be added to Table 12.2-69, however, it is not clear that Table 12.2-69 refers to the BAE Vent Condenser activity

   Please clarify the title of Table 12.2-69.

References

1. "Request for Additional Information No. 142-1733 Revision 1, SRP Section: 12.02 - Radiation Sources, Application Section: 12.2,", Question No.: 12.02-8" dated January 9, 2009 CHPB Branch (ADAMS Accession No. ML090410551)
2. "Request for Additional Information No. 142-1733 Revision 1, SRP Section: 12.02 - Radiation Sources, Application Section: 12.2,", Question No.: 12.02-9" dated January 9, 2009 CHPB Branch (ADAMS Accession No. ML090410551)

12.02-19

The US-APWR FSAR Revision 1 Tier 2 Sections 2 “Radiation Sources” describes design features that provide the bases for the shielding design calculations and the airborne radioactivity concentrations that provides the bases for the ventilation system design.

Supplemental Question SQ-3 derive from 143-1737

RAI 143-1737 Question 12.02-10 asked the applicant to provide the methods and assumptions for determining the airborne concentrations noted in Table 12.2-61 “Airborne Radioactivity Concentrations” and similar tables.

In summary, the Applicant Response indicated that:

1. They will revise Section 12.2 to provide a complete list of parameters and assumptions used for determining airborne activity concentrations.
2. Table 12.2-60 "Parameters and Assumptions for Calculating Airborne Radioactive Concentrations" will be revised,
3. Table 12.2-72 “Reactor Cavity And SFP Water Specific Activity In Refueling /Shutdown (Except Tritium)” will be added,

This response appears to be inadequate and inconsistent with other information provided by Applicant because:

1. The information provided in the revised Table 12.2-60 does not contain sufficient information to allow the staff to confirm the airborne activity concentrations provided in Table 12.2-61. For instance:
    a. The use of equation 12.2-1 to calculate airborne concentrations requires the use of unavailable room volumes and room flow rates so the λ removal factor can be determine.
    b. It is not clear that the information provided in Tables 12.2-61 (Sheets 1-6), "Airborne Radioactivity Concentrations" represents the maximum airborne concentrations in areas workers could expect to occupy. Insufficient information is available to the staff, to allow determination of the areas of maximum airborne activity concentration, due to room turn over rate, leakage rate and source strength.
2. Some of the information provided for Table 12.2-60 "Parameters and Assumptions for Calculating Airborne Radioactivity Concentrations is inaccurate or incomplete:
    a. Regarding Table 12.2-60 (Containment) (Sheet 1 of 3):
        I) The fraction of RAM to free volume during refueling for tritium is listed as 0.1. As there is no concentration mechanism in place for tritium evaporating from the pool surface, this value should be 1.0.
        II) The reference to Table 12.2-62 should actually be to Table 12.2-72.
        III) Purge Flow Duration for Low Volume Purge is listed as "Continuous", but Chapter 16 Technical Specifications section 3.6.3.2 indicates that the containment isolation valves are normally shut.
    b. Regarding Table 12.2-60 (Fuel Handling Area) (Sheet 2 of 3)":
        I) The reference to Table 12.2-62 should actually be to Table 12.2-72.
        II) The fraction of RAM to free volume during refueling for tritium is listed as 0.1. As there is no concentration mechanism in place for tritium evaporating from the pool surface, this value should be 1.0.
        III) Flow Rate is listed as 24,000 cfm, however, the staff is unable to ascertain the basis for this value.
    c. Regarding Table 12.2-60 (RB and AB) (Sheet 3 of 3)":
        I) A number of "Radiation Zones" are listed (III to VI). Since there are other zones depicted in Figures 12.1-1 sheets 1-34 "Radiation Zones for Normal Operation/Shutdown", and the RB and AB have piping and equipment areas containing these missing zones, it is not clear how the listed zones were derived and where they are defined.
        II) The assumed leakage rate provided is only for Refueling. The information provided is insufficient to allow determination of the assumed leakage rates for Operation at NOP/NOT.
        III) IF the depicted leakage rates are also for NOP/NOT conditions, THEN the minimum assessed leakage rate for any

area enclosing equipment containing ESF fluids, should not be less than the leakage rate assumed in Chapter 15 LOCA analysis.

IV) For those areas that enclose equipment that does not contain ESF fluids, the assumed leakage rates are not conservative for dose calculations, with respect to the Technical Specifications unidentified leakage rate of 1 gpm (12,000 lpd) or the identified leakage rate of 10 gpm (120,000 lpd)fluids. See the reply to Question 143-1737 12.02-11 MHI response.

3. The values in Table 12.2-72 do not appear to be consistent with the values in Table 12.2-52 “RHR System Activity – 4 Hours After Shutdown”, even when the Table 12.2-52 values are corrected for clean up to the EPRI Primary Water Chemistry Guidelines, and then diluted with distilled water (not RWSAT) to fill the Cavity.

Requested Information

1. Identify the limiting areas of airborne activity in each radiological section of the plant. Provide all of the parameters needed by Equation 12.2-1, the bases for selection of those values, and the resultant airborne concentrations for the limiting areas of the plant or provide the specific alternative approaches used and the associated justification.
2. Revise Table 12.2-60 Sheets 1 to 3, to address the specific concerns noted, or provide the specific alternative approaches used and the associated justification.
3. Provide the methods models and assumptions used to derive the values presented in Table 12.2-72.

References

1. "Request for Additional Information No. 143-1737 Revision 1, SRP Section: 12.02 - Radiation Sources, Application Section: 12.2,", Question No.: 12.02-10" dated January 9, 2009 CHPB Branch (ADAMS Accession No. ML090410551)

12.02-20

The US-APWR FSAR Revision 1 Tier 2 Sections 2 “Radiation Sources” describes design features that provide the bases for the shielding design calculations and the airborne radioactivity concentrations that provides the bases for the ventilation system design.

Supplemental Question SQ-4 derive from RAI 143-1737

RAI 143-1737 Question 12.02-11 asked the applicant to justify the use of a 100 lpd (~0.008 gpm) RCS leakage rate for calculating airborne activity levels for

occupational workers, considering that the Technical Specifications (TS) Unidentified Leakage rate (TSULR) limit is 1 gpm and the TS Identified Leakage rate (TSILR) limit is 10 gpm.

The Summary of the Applicant Response was:

1) The Safety Analysis for the TS allowable leakage rates did not consider airborne activity concentration limitations.
2) That the leakage rates in TS 3.4.13 also prevent the plant from exceeding the accident analyses radiation release assumptions.
3) The basis for the leak rate inside containment is taken from ANSI/ANS-55.6 “Liquid Waste Processing for Light Water Reactor Plants”,
4) They state that they believe the use of the lower leakage rate values is reasonable for the purpose of radiation protection.

It is true that the TS RCS leakage rate limit is based on Leak Before Break crack propagation criteria, and airborne activity concentrations are not a part of the TS leak rate safety analysis. However, SRP section 12.2 notes that review of airborne activity concentrations for dose assessment are to be based on normal operation, AOO and accident conditions. SRP Section 12.3-4 notes that the ventilation system is sized to maintain airborne activity concentrations less than 1 DAC in areas not normally occupied, where maintenance or inspections need to be performed.

However, the response to this RAI appears to be inadequate and inconsistent with other information provided by MHI because:

1) Insufficient information is presented to the staff in the US-APWR FSAR Tier 2, Chapters 11 and 15 to confirm the MHI assertion that the TS 3.4.13 also prevents the plant from exceeding the accident analysis radiation release assumptions. The leakage rates value used in Table 11.2-9 and Table 15.4.8-3 are much less that the leakage rate values listed in TS 3.4.13.

   Provide sufficient information to allow the staff to confirm the statement by MHI that TS 3.4.13 also prevents the plant from exceeding the accident analyses radiation release assumptions.

2) The leakage rate used by the Applicant are not representative of documented industry experience and would present non-conservative estimates of Occupational Radiation Exposure for personnel entering affected areas.

   The value from ANSI/ANS-55.6 is used for determining the average liquid processing capacity required over the course of cycle. This is an appropriate value to use when the waste storage tanks act as a smoothing function for variable leak rates. However, the airborne activity concentrations within closed volumes, such as the Containment Building, are tightly linked with the instantaneous leakage rates. This tight linkage is the basis of the Regulatory Guide 1.45 position statement requirement for a Radiation Monitor based RCS leakage detection method. Based on NRC Staff OE it is not uncommon to have RCS Leakage rates inside containment well in excess of the MHI assumed leakage rate. This experience is corroborated by information

presented in NUREG/CR-6861 “Barrier Integrity Research Program”, Figure 17 “Distribution of Leak Rates” which documents more than 100 leaks above 0.015 gpm (180 lpd) and more than 50 leaks greater than 1 gpm (12005 lpd). Also, WCAP-16465-NP Revision 0 “Pressurized Water Reactor Owners Group Standard RCS Leakage Action Levels and Response Guidelines for Pressurized Water Reactors” notes action levels that are well in excess of 100 lpd, including:

a) The 0.15 gpm two consecutive day values noted in Section 5.2.1 “Absolute Unidentified Leak Rate Action Levels”,
b) The 0.3 gpm one daily RCS leakage rate

Even at a WCAP-16465-NP Tier Three Action Level leak, the corrective action may only involve identification of the source of leakage, and initiating a plan to correct the leak. This document further notes that RCS operational LEAKAGE shall be limited to 1 gpm unidentified leakage, and 10 gpm identified leakage. WCAP-16465 is not referenced in Chapters 5 or Chapter 16, so the lower values of leakage noted in this document may not be applicable. Therefore, the RCS Leakage Rate of 100 lpd (0.008 gpm) for normal operation is not conservative for dose calculations when using the Technical Specifications unidentified leakage rate of 1 gpm (12,000 lpd) or the identified leakage rate of 10 gpm (120,000 lpd).

Based on the guidance provided in SRP Section 12.2, the operating experience described by NUREG/CR-6861, and the program description described by WCAP-16465-NP, provide leakage rate assumptions consistent with Technical Specification leakage rate limits, or justify the use of 100 lpd RCS leakage rate for conservatively determining ORE airborne activity concentrations inside containment.

References

1. "Request for Additional Information No. 143-1737 Revision 1, SRP Section: 12.02 - Radiation Sources, Application Section: 12.2,", Question No.: 12.02-11" dated January 9, 2009 CHPB Branch (ADAMS Accession No. ML090410551)

12.02-21

The US-APWR FSAR Revision 1 Tier 2 Sections 2 “Radiation Sources” describes design features that provide the bases for the shielding design calculations and the airborne radioactivity concentrations that provides the bases for the ventilation system design.

Supplemental Question (SQ-5) derive from RAI 144-1738

RAI 144-1738 Question 12.02-12, asked the applicant to provide information regarding the thickness of the concrete walls surrounding the outside storage tanks for Primary Water Storage and Refueling Water Auxiliary Storage.

In summary, the MHI Response indicated that:

1. The design is being changed to remove the concrete shield walls, and that:
    a. Procedures will be adopted to control the activity in the tank to limit the dose rate to 0.25 mrem/h at 2 meters.
    b. Barriers will be installed at 2 meters from the tank to limit personnel access.
2. Section 12.2.1.1.10 and Tables 12.2-50, 51 and 12.3-1 will be revised to include activity concentrations for the Refueling Water Storage Auxiliary Tank, and the Primary Makeup Water Tank.

This response appears to be inadequate and inconsistent with other information provided by MHI because:

1. The response notes that following the removal of concrete shield walls procedures will be used to control the activity in the tank to limit the dose rate to 0.25 mrem/h at 2 meters. However, there is no corresponding COL action item in section 12.2.3 “Combined License Information”.
2. The response indicated that barriers would be installed 2 meters from the tank to limit access to the area around the tanks. Contrary to this statement Figure 12.3-1 “Radiation Zones for Normal Operation/Shutdown Site (Sheet 1 of 34)”, has not been modified to show the barriers, nor has a COL action item been added to section 12.2.3 “Combined License Information” to address the installation of these barriers.
3. Figure 12.3-1 was not changed to indicate that the areas around the tanks and inside of the barriers would be a higher radiation zone.
4. While the response indicated that the concrete walls would be removed, it did not describe the design features of the areas around the tanks that will support the requirements of 10 CFR 20.1406, with respect to minimizing contamination of the environment.

Requested Information

1. Please identify the COL action item in Section 12.2.3 that addresses the procedural guidance for limiting the amount of activity that may be added to these tanks.
2. Please modify figure 12.3-1 to show the barriers referenced in the response, or add a COL action item in Section 12.2.3 to provide this information.
3. Please modify figure 12.3-1 to show that the dose rates inside of these barriers is a higher zone.
4. Please describe the design features of the areas around the tanks will support the requirements of 10 CFR 20.1406, with respect to minimizing contamination of the environment.

<u>References</u>

1. "Request for Additional Information No. 144-1738 Revision 1, SRP Section: 12.02 - Radiation Sources, Application Section: 12.2,", Question No.: 12.02-12" dated January 9, 2009 CHPB Branch (ADAMS Accession No. ML090410551)

12.02-22

The US-APWR FSAR Revision 1 Tier 2 Sections 2 “Radiation Sources” describes design features that provide the bases for the shielding design calculations and the airborne radioactivity concentrations that provides the bases for the ventilation system design.

Supplemental Question (SQ-6) derive from RAI 168-1739

RAI 168-1739 Question 12.02-14, asked the applicant to provide information regarding the assumptions used to calculate resin activity.

This response appears to be inadequate or incomplete for the following reason:

1. Table 12.2-1 listed effective density values to be used for shielding calculations, for a number of components (e.g. Steam Generator, Regenerative and Excess Let Down Heat Exchangers) that do not match stated w/% in the materials column.

Requested Information

1. Please correct the density values provided in Table 12.2-1 or provide the specific alternative approaches used and the associated justification.

<u>References</u>

1. "Request for Additional Information No. 168-1739 Revision 1, SRP Section: 12.02 - Radiation Sources, Application Section: 12.2,", Question No.: 12.02-14" dated February 3, 2009 CHPB Branch (ADAMS Accession No. ML090650632)