Jeff Ciocco

From: Jeff Ciocco
Sent: Tuesday, September 02, 2008 3:59 PM
To: us-apwr-rai@mhi.co.jp
Cc: James ODriscoll; Christopher Jackson; Ruth Reyes; Larry Burkhart
Subject: US-APWR Design Certification Application RAI 62-655
Attachments: US-APWR DC RAI 62 SPCV 655.pdf

MHI,

Attached please find the subject request for additional information (RAI). This RAI was sent to you in draft form. The schedule we established for review of your application assumes technically correct and complete responses within 30 days of receipt of RAIs. Please submit you RAI response to the NRC Document Control Desk.

Thanks,

Jeff Ciocco
Office: T-7F14
New Reactor Licensing
U.S. Nuclear Regulatory Commission
11555 Rockville Pike
Rockville, MD 20852-2739
301.415.6391
jeff.ciocco@nrc.gov

REQUEST FOR ADDITIONAL INFORMATION NO. 62-655 REVISION 0

9/2/2008

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

SRP Section: 06.02.05 - Combustible Gas Control in Containment

Application Section: 6.2.5

SPCV Branch

QUESTIONS

06.02.05-1

(6.2.5-1)
Provide additional information about the assumptions used to in the calculations demonstrating the effectiveness of the CHS.

The requirements in 10 CFR 50.44(c)(1),(2) and (5) and in 10 CFR 50.34(f)(2)(ix) and (3)(v) focus on the aspects of the needed hydrogen control. Conformance to these requirements is briefly addressed in Section 6.2.5 and in more detail in Section 19.2.3.3.2 of the DCD. In Section 19.2.3.3.2 the DCD notes that the GOTHIC code was used to evaluate the effectiveness of the hydrogen igniter system, and that the hydrogen generation rate was evaluated with MAAP plus independently calculated amounts of hydrogen generation. Additional detail regarding the assumptions used for this analysis is needed. In particular, describe (1) the accident scenarios assumed for the MAAP calculation(s), (2) the generation rates produced by MAAP, (3) the sensitivity cases, if any, conducted with MAAP and their results for hydrogen generation rates and containment pressures, and (4) the independently calculated hydrogen generation rates used and the resulting containment pressures.

06.02.05-2

(6.2.5-2)
Provide additional detail regarding the assumptions used for the atmospheric mixing part of both the Severe and the Design Basis Accident calculations.

10 CFR 50.44(c)(1) states that all containments must have a capability for ensuring a mixed atmosphere during design-basis and significant beyond design-basis accidents. The DCD briefly discusses mixing of the containment atmosphere in Section 6.2.5 and provides a sketch of typical air flow patterns in Figure 6.5.2-2. In Section 19.2.3.3.2 the discussion on the GOTHIC calculations used to evaluate the effectiveness of the hydrogen ignition system in severe accidents mentions that these calculations included evaluation of atmospheric mixing. However, no additional information on atmospheric mixing is provided. Provide additional detail regarding the assumptions used for the atmospheric mixing part of both the severe and the DBA analyses. In particular, describe (1) the modeled internal structures of the containment that promote and permit the

mixing of gases within the containment and sub compartments, (2) any dead ended containment areas identified where hydrogen may not be adequately mixed, (3) the accident scenarios assumed, including primary system failure locations and mass flow composition and rates into containment, (4) the role of the containment spray system in the calculations, (5) analysis/assumptions and mathematical models that ensure that hydrogen does not accumulate within any sub compartment to the level that would support a combustible/detonatable mixture, (6) provide a list by compartment of the calculated hydrogen concentrations by volume, and (7) discuss how it is assured that any hydrogen discharge from the high point vents is mixed into the containment atmosphere and not left to accumulate in any subcompartment.

06.02.05-3

(6.2.5-3)
Clarify the capability to address potential hydrogen accumulation of the steam inerted compartments when those compartments change from an inerted condition to a flammable condition.
Section 19.2.3.3.2 of the DCD application provides the result of the analysis that shows that sub compartments are either inerted by steam or less than 10% volume hydrogen. The change of a compartment from an inerted condition to a flammable condition is not discussed.
In order to evaluate whether the US-APWR combustible gas control system design meets the requirements of 10 CFR Part 50, § 50.44, 50.34(f)(2)(ix), and GDC41, to control the concentration of H2 in the containment atmosphere and of GDC 41 to provide systems as necessary to ensure that containment integrity is maintained, additional information is needed. Provide a discussion on capabilities to address potential hydrogen accumulation of the steam inerted compartments when those compartments change from an inerted condition to a flammable condition.

06.02.05-4

(6.2.5-4)
Clarify if there is an alarm in the main control room (MCR) for the hydrogen monitor.

In meeting the requirements of 10 CFR Part 50, § 50.44, and GDC 41 regarding the functional capability of the combustible gas control systems to ensure that containment integrity is maintained, the US-APWR hydrogen detector system should meet the provisions of SRP chapter 6.2.5 acceptance criterion #6b. In order to evaluate the US-APWR hydrogen monitoring system as it related to satisfying this criterion, more information is required. Clarify (or indicate where in the DCD it is confirmed) if there is an alarm in the MCR for the hydrogen monitor.

06.02.05-5

(6.2.5-5)
Indicate if the Hydrogen Control System is designed with the capability to remain operable assuming a single failure such as a failure of one igniter or igniter power

supply. Discussion of the response of the hydrogen control system assuming a single failure is not provided.

In meeting the requirements of 10 CFR Part 50, § 50.44, and GDC 41 regarding the functional capability of the combustible gas control systems to ensure that containment integrity is maintained, the US-APWR design should meet the provisions of RG 1.7, Revision 3, Section C.1. In order to evaluate whether the USAPWR meets the requirements of RG 1.7, Revision 3, Reference 7, more information is required. Indicate (or reference where in the DCD it is indicated) if the Combustible Gas Control System is designed with the capability to remain operable assuming a single failure such as a failure of one igniter or igniter power supply. Were calculations carried out with only one train (i.e., one power supply) of igniters operating? If so, describe where the results differed from those with both trains operating. Include a discussion on details of the analysis that was performed for igniter placement in this discussion, i.e. were the distances between igniters (igniter coverage) evaluated to ensure a low probability of flame acceleration, by location of the igniter close to likely hydrogen release points, and was there any considerations in the event that one or more igniters fail to function? Indicate if there are any compartments not covered by an igniter and if any, provide justification.

06.02.05-6

(6.2.5-6)
Indicate the capability of the CHS to withstand the SSE without loss of function.

As noted in Tier 1, Section 2.11.4.1, of the DCD the hydrogen monitoring and control system is not safety related and is not designed for seismic Category 1 requirements. However, the CHS is an important system for plant protection for beyond-design-basis accidents. More information on the seismic ruggedness of the CHS is needed.

In meeting the requirements of 10 CFR Part 50, § 50.44, and GDC 41 regarding the functional capability of the combustible gas control systems to ensure that containment integrity is maintained, the US-APWR design should meet the provisions of RG 1.7, Revision 3, Section C.1. Per RG 1.7, the Combustible gas control system equipment reliability expectations under severe accident conditions should consider the circumstances of applicable initiating events (such as earthquakes). As noted in Tier 1, Section 2.11.4.1, the hydrogen monitoring and control system is not safety related and is not designed for seismic Category 1 requirements. Indicate (or reference where in the DCD it is indicated) if the CHS is designed with the capability to withstand the SSE without loss of function. Explain how, in the case of such event, the components of the CHS do not have the potential to adversely affect other safety related components in containment.

06.02.05-7

(6.2.5-7)
Provide more specific design information on the components of the CHS. Table 6.2.5-1 of the DCD provides very general CHS design parameters, and Section 19.2.3.3.7 of the DCD discusses equipment survivability, but more design details are needed.

In meeting the requirements of 10 CFR Part 50, § 50.44(c)(3), regarding equipment survivability, equipment necessary for achieving and maintaining safe shutdown of the plant and maintaining containment structural integrity should perform its safety function during and after being exposed to the environmental conditions attendant with the release of hydrogen generated by the equivalent of a 100 percent fuel clad-coolant reaction including the environmental conditions created by activation of the combustible gas control system. In order to evaluate if the US-APWR CHS meets this criteria when constructed:

1) Indicate what specific design basis information for the components of the CHS reflect the results of the referenced 19.2.3.3.7 evaluation, and DCD reference 19.2-58.

2) Provide a design description of the hydrogen igniter to be supplied for the US-APWR, and its associated power supplies, transformers and cabling etc, to include performance criteria sufficient to support that such igniter, when installed, will have similar performance as those described in DCD reference 19.2-58.

06.02.05-8

(6.2.5-8)

Provide additional information on how inspection and test requirements of GDCs 41, 42 and 43 are met.

To satisfy the inspection and test requirements of GDC 41, 42, and 43, combustible gas control systems including hydrogen igniters and combustible gas monitors should be designed with provisions for periodic inservice inspection, operability testing, and leak rate testing of the systems or components. The tests should support the analyses of the functional capability of the equipment. In order to evaluate this requirement as it applies to the US-APWR CHS, additional information is required:

1) Provide details on the design features of the hydrogen monitoring system and the hydrogen ignition system that accommodate periodic inspection and testing to assure system integrity and operability of the systems active components.

2) Describe how proposed inservice test criteria will be established and on what design requirements the test criteria will be based.

3) In order to evaluate if the proposed design is capable of achieving the required overall system design basis performance goal of maintaining hydrogen in the containment atmosphere to less than 10% (by volume), provide additional performance data on the hydrogen igniter system such as: performance requirements for each igniter (i.e.) minimum igniter surface temperature, voltage and current. Also indicate the design criteria to be verified in the in-service tests and inspections. Provide a description of the in-service performance test, or indicate if the description of the in-service test and inspection program will be a COL item.

06.02.05-9

(6.2.5-9)
Provide a discussion of design requirements to ensure reliability, availability and capability of hydrogen detection system. Design requirements for this single instrument are not provided.

In meeting the requirements of 10 CFR Part 50, § 50.44, and GDC 41 regarding the functional capability of the combustible gas control systems to ensure that containment integrity is maintained, the US-APWR H2 detector system should meet the provisions of RG 1.7, Revision 3, Section C.2. Provide a discussion of design requirements to ensure reliability, availability and capability of this single instrument.

06.02.05-10

(6.2.5-10)
Discuss the accessibility of the CIV's of the PASS for manual operation during a severe accident.

In meeting the requirements of 10 CFR Part 50, § 50.44, and GDC 41 regarding the functional capability of the combustible gas control systems to ensure that containment integrity is maintained, the US-APWR H2 detector system should meet the provisions of RG 1.7, Revision 3, Section C.2. In order to evaluate the US-APWR hydrogen monitoring system as it related to satisfying the criteria of RG 1.7, Revision 3, Section C.2.1(7), provide a discussion as to the accessibility of the CIV's of the PASS for manual operation during a severe accident.

06.02.05-11

(6.2.5-11)
Discuss why the operating principle and accuracy of the combustible gas analyzer are provided by the COL applicant.

In meeting the requirements of 10 CFR Part 50, § 50.44, and GDC 41 regarding the functional capability of the combustible gas control systems to ensure that containment integrity is maintained, the US-APWR hydrogen detector system should meet the provisions of RG 1.7, Revision 3, Section C.2. 10 CFR 52.47 (c)(1) states that an application for certification of a nuclear power reactor design that is an evolutionary change from light–water reactor designs of plants that have been licensed before April 18, 1989, must provide an essentially complete nuclear power plant design. In order to evaluate the US-APWR hydrogen monitoring system as it related to satisfying the criteria of RG 1.7, Revision 3, Section C.2 more information is required. Discuss why the operating principle and accuracy of the combustible gas analyzer is provided by the COL applicant (COL 6.2(7)).

06.02.05-12

(6.2.5-12)
Indicate how information on tests conducted to demonstrate the performance capability of the hydrogen analyzer will be verified following the construction phase, and how criteria for the Hydrogen Analyzer design will be verified. More information than is provided in Section 14.2.12.1.64 of the DCD is needed.

In meeting the requirements of 10 CFR Part 50, § 50.44, and GDC 41 regarding the functional capability of the combustible gas control systems to ensure that containment integrity is maintained, the US-APWR hydrogen detector system should meet the provisions of RG 1.7, Revision 3, Section C.2. In order to evaluate the US-APWR hydrogen monitoring system, as it relates to satisfying this section, more information is required. Indicate how information on tests conducted to demonstrate the performance capability of the hydrogen analyzer will be verified following the construction phase, and how criteria for hydrogen analyzer design specified in RG 1.7, Section C.2 will be verified.

06.02.05-13

(6.2.5-13)
Clarify if a failure mode and effects analyses (FMEA) of the combustible gas control system, i.e., the hydrogen ignition system, was performed for the Probabilistic Risk Assessment. The DCD mentions the use FMEA in a general way in chapter 19 but no discussion is provided.

In meeting the requirements of 10 CFR Part 50, § 50.44, and GDC 41 regarding the functional capability of the combustible gas control systems to ensure that containment integrity is maintained, the US-APWR CHS should meet the provisions of RG 1.7, Revision 3, Section C.2. In order to evaluate the US-APWR combustible gas control system as it related to satisfying the criteria of RG 1.7, Revision 3, Section C.2 more information is required. The DCD mentions the use of failure mode and effects analyses (FMEA) in a general way in chapter 19. No discussion of a FMEA for the hydrogen ignition system is provided. Was a FMEA of the hydrogen ignition system performed for the Probabilistic Risk Assessment? If not, provide justification for not conducting a FMEA on this system. If a FMEA was carried out for the system, provide a list of failure modes considered, and the modes included in the PRA model.

06.02.05-14

(6.2.5-14)
Provide the assumptions that were used in the CHS effectiveness calculations for the generation of hydrogen from the inventory of materials within the containment that would yield hydrogen gas by corrosion from the ECCS or containment spray solutions.

SRP 6.2.5 acceptance criteria #1 and RG 1.7 Revision 3 Section C, paragraph 4, refer to the identification of materials within the containment that would yield hydrogen gas by corrosion from the ECCS or containment spray solutions. Provide the assumptions used in the accident progression analyses for hydrogen generation and control,

described in Chapter 19.2.3.3.2, for the generation of hydrogen from the inventory of such materials within the containment.

06.02.05-15

(6.2.5-15)
Indicate and justify what, if any, inspections, test analysis and acceptance criteria would be required to verify that the hydrogen load produced by materials within the containment that would yield hydrogen gas would not exceed the hydrogen load assumptions used in the severe accident progression analysis contained in the design certification.

COL Item Number 6.1(4) states that "The COL applicant is responsible to identify materials within the containment that would yield hydrogen gas by corrosion from the emergency cooling or containment spray solutions, and their use should be limited as much as practicable." In support of meeting the requirements of 10 CFR Part 50, § 50.44, and GDC 41 and pursuant to SRP 6.2.5 acceptance criteria #1 and RG 1.7 revision 3 section C, paragraph 4, describe (or indicate where in the DCD it is described) any specific criteria to be used by a COL applicant to demonstrate that the use of such materials were minimized during construction. Indicate and justify what if any inspections, test analysis and acceptance criteria (ITAAC) would be required to verify that the hydrogen load produced by such materials would not exceed the hydrogen load assumptions used in the severe accident progression analysis contained in the design certification.

06.02.05-16

(6.2.5-16)
Clarify if a failure mode and effects analyses (FMEA) of the containment hydrogen monitoring system was performed. The DCD mentions the use FMEA in a general way in chapter 19 but no discussion is provided.

In meeting the requirements of 10 CFR Part 50, § 50.44, and GDC 41 regarding the functional capability of the combustible gas control systems to ensure that containment integrity is maintained, the US-APWR design should meet the provisions of RG 1.7, Revision 3, Section C.1. In order to evaluate whether the USAPWR meets the requirements of RG 1.7, Revision 3 Reference 7, more information is required. Was a FMEA of the containment hydrogen monitoring system performed? If not, provide justification for not conducting a FMEA on this system. If a FMEA was carried out for the system, provide a list of failure modes considered, and the conclusions of the analysis.

06.02.05-17

(6.2.5-17)
Indicate what ITAAC will be used to confirm the adequacy of the igniter capability, including design criteria to be verified, and the ITACC acceptance criteria for igniter location.

10 CFR 52.47 (c)(1) states that an application for certification of a nuclear power reactor design that is an evolutionary change from light–water reactor designs of plants that have been licensed before April 18, 1989, must provide an essentially complete nuclear power plant design. To satisfy the design requirements of GDC 41, performance tests should be performed on system components, such as hydrogen igniters and combustible gas monitors. The tests should support the analyses of the functional capability of the equipment. In order to evaluate this requirement, provide a description of what design criteria will be verified in the pre-service tests of the CHS. Indicate what ITAAC will be used to confirm the adequacy of the igniter capability including design criteria to be verified and the ITACC acceptance criteria for igniter location.

06.02.05-18

(6.2.5-18)
Provide a discussion of how the design addresses the installation of non safety related equipment such that it does not adversely affect safety related equipment, and how measures are established to ensure that purchased material, equipment, and services conform to the procurement documents.

In meeting the requirements of 10 CFR Part 50, § 50.44, and GDC 41 regarding the functional capability of the combustible gas control systems to ensure that containment integrity is maintained, the US-APWR design should meet the provisions of RG 1.7, Revision 3, Section C.1. In order to evaluate whether the USAPWR meets the requirements of RG 1.7, Revision 3 Reference 7, provide a discussion of how the design addresses the following criteria:

- Installation of non safety related equipment such that it does not adversely affect safety related equipment (i.e. is independent from safety related equipment)(Appendix A)
- Measures to assure that all design related guidelines used to comply with 10 CFR 50.44 and 10 CFR 50.34(f)(2)(ix), GDC 5, 41, 42 and 43 is carried forward to procurement documents (appendix A) and that deviations there from are controlled.
- Measures should be established to ensure that purchased material, equipment, and services conform to the procurement documents.

~

06.02.05-19

(6.2.5-19)
Clarify whether the load associated with dead load plus 45 psig, would result in higher containment loadings than would result from the loads associated with the releases of hydrogen generated from 100% metal-water reaction of the fuel cladding and accompanied by uncontrolled hydrogen burning.

In section 3.8.1.3.2.2 of the DCD a discussion is provided on how the US-APWR containment structural design satisfies the requirements of Subarticle CC-3720 of the

ASME code Section III for factored load design. It is stated that since the design meets the minimum design condition of D+45 psig (RG1.136, Revision 3, Section C.5.B.(3)), the design does not require a design evaluation. Clarification is needed.

In meeting the requirements of 10 CFR Part 50, § 50.44(c)(3) and § 50.44(c)(5), requirements that containment structural integrity be demonstrated by an analysis acceptable to the NRC staff, the US-APWR design should meet the provisions of RG 1.7, Revision 3, Section C.5. In order to evaluate whether the USAPWR meets the requirements of this section more information is required. In section 3.8.1.3.2.2 of the DCD a discussion is provided on how the US-APWR containment structural design satisfies the requirements of Subarticle CC-3720 of the ASME code Section III for factored load design. It is stated that since the design meets the minimum design condition of D+45 psig (RG1.136, Revision 3, Section C.5.B.(3)), the design does not require a design evaluation. Clarify whether the load associated with dead load plus 45 psig, would result in higher containment loadings than would result from the loads associated with the releases of hydrogen generated from 100% metal-water reaction of the fuel cladding and accompanied by uncontrolled hydrogen burning. If this is not the case, provide additional information that demonstrates that containment structural integrity will be maintained in such an event.

06.02.05-20

(6.2.5-20)
Clarify information in DCD Chapter 1 Table 1.9.3-2.

10CFR50.34(f)(2)(ix) is not included in DCD Chapter 1 Table 1.9.3-2., 'Location of Description for Additional TMI-Related requirements', However Section 6.2.5.1 of the DCD states that the containment hydrogen monitoring and control system is designed in accordance with 10CFR50.34(f)(2)(ix). Clarify this by amending the table or the Section 6.2.5.1 as appropriate.

06.02.05-21

(6.2.5-21)
Clarify RG 1.7 title reference in DCD section 6.2.5-1.

DCD section 6.2.5.1 incorrectly refers to the title of RG 1.7 as "Control of Combustible Gas Concentrations in Containment following a loss of Coolant Accident" This is the title of the previous version of the RG (Revision 2) The title of the current version of the RG is "Control of Combustible Gas Concentrations in Containment". You reference RG 1.7 Revision 3 in reference 6.2-29. Confirm that the containment hydrogen monitoring and control system is designed in accordance with RG 1.7 Revision 3.