REQUEST FOR ADDITIONAL INFORMATION 269-1898 REVISION 1

3/9/2009

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

QUESTIONS for Containment and Ventilation Branch 1 (AP1000/EPR Projects) (SPCV)

06.02.05-22

RAI 6.2.5-22:
Provide additional information about the assumptions used in the calculations demonstrating the effectiveness of the CHS.

The staff requested, in RAI 6.2.5-1 that the applicant provide additional detail regarding the assumptions used for the hydrogen generation rate and the effectiveness of the hydrogen igniters. In particular, the applicant was asked to 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.

The applicant provided the following response:

Please refer to the technical report "US-APWR Probabilistic Risk Assessment" (MUAP-07030) Chapter 15 Separate Effect Analysis. Section 15.3 of this report describes the discussion on the hydrogen generation and control; and the particular information requested in the items (1) through (4) can be found there. (1), (2) and (3): Discussed in Subsection 15.3.3.2 (4): Discussed in Subsection 15.3.3.3 and 15.3.3.4

The staff has reviewed this response and the referenced technical report and has identified that the following needs to be addressed by the applicant

1) Per 10 CFR 52.47(a)(12), all applicants for a reactor operating license shall include the analyses and the descriptions of the equipment and systems required by 10 CFR 50.44 as part of their application. Therefore, the information contained in subsections 15.3.3 and 15.3.4, and 15.7.3 of MUAP-07030, including all figures referenced therein shall be supplied, as part of Section 6.2.5 of the DCD application, since this analysis information is used to evaluate the adequacy of the Combustible Gas Control System design.

2) It appears that some graphs of the peak hydrogen concentrations in some nodes have been cut off in Figures 15-13 to 15-25. Please supply the peak hydrogen concentrations reached in each node for each of the two accident

scenarios evaluated. In particular, please provide the peak hydrogen concentration in the following nodes:

AD Sequence, Node 2
AD Sequence, Node 30
TMLD_DP Sequence Node 4
TMLD_DP Sequence Node 2
TMLD_DP Sequence Node 30

06.02.05-23

RAI 6.2.5-23:
Provide additional detail regarding the assumptions used for the atmospheric mixing part of both the Severe and the Design Basis Accident calculations.

The staff requested, in RAI 6.2.5-2 that the applicant provide additional detail regarding the assumptions used for the atmospheric mixing part of both the severe and the DBA analyses. In particular, the applicant was requested to (1) describe the modeled internal structures of the containment that promote and permit the mixing of gases within the containment and sub compartments, (2) describe any dead ended containment areas identified where hydrogen may not be adequately mixed, (3) describe the accident scenarios assumed, including primary system failure locations and mass flow composition and rates into containment, (4) describe the role of the containment spray system in the calculations, (5) describe 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.

The applicant provided the following response:

Regarding atmosphere mixing under the postulated severe accident conditions, please refer to the technical report "US-APWR Probabilistic Risk Assessment" (MUAP-07030) Chapter 15 Separate Effect Analysis.. Section 15-3 of this report describes the discussion on the hydrogen generation and control; and the particular information requested in the items (1) through (7) can be found there.

(1) Discussed in Subsection 15.3.3.4.1. This GOTHIC model is based on the lumped model and the each detailed internal structure is not considered, but treated as volumetric bulk within the compartment. Atmosphere mixing inside the containment is referenced from the literature 15-4 specified in the report.

(2) Discussed in Subsection 15.3.3.4.1. No dead ended areas are identified for the US-APWR. This also references the literature 15-4 specified in the report.

(3) Discussed in Subsection 15.3.3.2 for the accident scenarios and in Subsection 15.3.3.4.1 for the hydrogen release locations, flow rates, etc.

(4) Discussed in Subsection 15.3.3.2.

(5) Discussed in Subsection 15.3.3.4 and 15.3.3.5.

(6) Discussed in Subsection 15.3.3.4.1.

(7) Discussed in Subsection 15.3.3.4 and 15.3.3.5.

Furthermore, MHI considers that the calculation for atmosphere mixing under the postulated severe accident conditions represents the capability of mixing atmosphere in containment both during design-basis and beyond design-basis accidents.

The staff has reviewed this response and the referenced technical report and has identified that the following needs to be addressed by the applicant:

Per 10 CFR 52.47(a)(12), all applicants for a reactor operating license shall include the analyses and the descriptions of the equipment and systems required by 10 CFR 50.44 as part of their application. Therefore, the information contained in Subsections 15.3.3 and 15.3.4, and 15.7.3 of MUAP-07030, including all figures referenced therein shall be supplied, as part of Section 6.2.5 of the DCD application, since this analysis information is used to evaluate the adequacy of the Combustible Gas Control System design.

With regard to why hydrogen discharged from the high point vents will be well mixed in the containment atmosphere the reference to MUAP Subsections 15.3.3.4 and 15.3.3.5 was not very helpful. These sections are general and there is no reference to the high point vents. A discussion that provides the reasons why the high point vent discharge can be expected to be well mixed is needed. Please provide such a discussion. In Chapter 5 of the DCD, where the high point vents are discussed, the statement is made that “Vent areas should provide good mixing with containment air” but no details are provided. Subsection 5.4.12 indicates that the vents would be in the reactor vessel head and in locations connected to the pressurizer. The discussion could explain how these locations compare with the hydrogen release points chosen for the atmospheric mixing calculations carried out as part of the analysis described in Chapter 15 of MUAP-07030.

In addition, the NRC does not agree with MHI’s statement that the calculation for atmosphere mixing under the postulated severe accident conditions represents the capability of mixing atmosphere in containment both during design-basis and beyond design-basis accidents.

The provided severe accident analysis credited steam inerting after reactor vessel breach in some compartments as the means by which a non combustible atmosphere is achieved. In some LOCA and severe accident scenarios, the RCS may not breach, steam concentrations may be lower or nonexistent, and containment spray may not be on. Per 10 CFR 50.44 (a)(2) a mixed atmosphere means that the concentration of combustible gases in any part of the containment is below a level that supports combustion or detonation that could cause a loss of containment integrity. Please provide:

a) An analysis that supports adequate containment mixing during a postulated LOCA.
b) An analysis that addresses atmospheric mixing and hydrogen concentrations in containment in a severe accident that does not result in a core breach, and/or results in “late” sprays (such as TMI for example).

06.02.05-24

RAI 6.2.5-24:
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.

The staff requested, in RAI 6.2.5-3 that the applicant 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. 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.

The applicant provided the following response:

MHI understands the NRC's concern, and recognizes the point that the NRC commented is one of the biggest issues of usage of the hydrogen igniters for controlling the in-containment hydrogen concentration.

Hydrogen igniters are provided for the US-APWR in order to rapidly and properly control the hydrogen concentration below the detonable range during accidents to prevent explosive combustion of hydrogen and maintain the containment integrity. However in case the atmosphere of compartment is inert, it is impossible to properly control the hydrogen concentration by hydrogen igniters. Alternatively, the containment integrity should be maintained through the rigidly determined operational procedures, not to change the compartment atmosphere composition from an inert condition to a detonable condition immediately. Under this situation, the inert gas of the atmosphere is considered steam. Large amount of steam makes the atmosphere inert although it adversely pressurizes the containment if the amount is too much. In order to prevent over-pressure failure of the containment, operational action should be primarily taken to depressurize the containment. The steam concentration decreases as the containment depressurization operation progresses and the atmosphere conditions changes to flammable when the steam concentration becomes below approximately 55%. Therefore, the operational procedure should be determined how to control the steam concentration. It is widely observed that the hydrogen combustion speed and the explosive load become lower in the higher steam concentration. The operational procedure should therefore indicate not to rapidly depressurize the *containment vessel to very low pressure, instead maintain it relatively high around the hydrogen flammable limit condition. In order to achieve this operation, accurate measurement of the hydrogen detector is also important. This detailed operational procedure will be developed as a part of the severe accident management program, identified as one of the COL items specified in Subsection 19.2.5 of the DCD.*

The staff has reviewed this response and the referenced technical report and has identified that the following needs to be addressed by the applicant.

In a letter dated November 7,2008 the applicant informed the NRC that the above mentioned COL item, in DCD subsection 19.2.5 will be deleted. (COL item 19.3(6)) In consideration of this change, In order to evaluate whether the US-APWR combustible gas control system design meets the requirements of 10 CFR Part 50, § 50.44, 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, 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. Provide details of operator actions required to assure a non combustible atmosphere in containment and the integrity of containment during the course of a postulated severe accident involving the US-APWR.

06.02.05-25

RAI 6.2.5-25:
Clarify if there is an alarm in the main control room (MCR) for the hydrogen monitor.

The staff requested, in RAI 6.2.5-4 that the applicant clarify if there is an alarm in the main control room (MCR) for the hydrogen monitor.

The applicant provided the following response:

MHI intends to provide an alarm in the main control room for the hydrogen detector. The actual design of this alarm, such as when it is alarmed, what alarm is given, etc., is determined in conjunction with the discussions provided in the RAI Question No.06.02.05-3, etc. The signal transmitted from the hydrogen detector is not utilized to control other system, although the detector measurement should be suitably applied for plant operators to maintain the containment integrity.

This alarm is one of the plant specific designs in relation to the severe accident management program, which is discussed in Subsection 19.2.5 of the DCD.

The staff has reviewed this response and the referenced technical report and has identified that the following needs to be addressed by the applicant:

1) Since the applicant indicates that a hydrogen alert function will be supplied, state in the DCD section 6.2.5 that an alarm function in the

MCR will be provided. Provide ITAAC to verify existence (minimum inventory of alarms criterion).

2) In a letter dated November 7, 2008 the applicant informed the NRC that COL item 19.3(6), to develop an accident management program which would satisfy RG 1.206 Appendix C.I.19A-19.2.5 guidance, will be deleted. Applicants for a Design Certification should describe those actions taken during the course of accidents to maintain containment integrity. In consideration of this change, 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, submit information on the performance requirements of the alarm (i.e., when it is alarmed, what type of alarm), and how such alarm would work with operator actions such that SRP AC #6b can be evaluated.

06.02.05-26

RAI 6.2.5-26:
Indicate the capability of the CHS to withstand the SSE without loss of function.

The staff requested, in RAI 6.2.5-6 that the applicant indicate if the CHS is designed with the capability to withstand the SSE without loss of function, and 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.

The applicant provided the following response:

MHI agrees with the NRC's concern that the CHS is an important system to protect the plant safety during beyond-design-basis accident, such as an event that core is significantly damaged. As stated in Tier 1, Section 2.11.4.1 of the DCD, the CHS is not designed for seismic category I requirements since this system is required for plant protection for beyond design-basis accident. However, in considering the importance of the hydrogen igniters in order to maintain the containment integrity during postulated severe accidents, it is intended to design satisfying the plant HCLPF (high confidence of low probability failure) is evaluated more than 0.5G.

The staff has reviewed this response and the referenced technical report and has identified that the following needs to be addressed by the applicant:

Add the RAI response to Tier 2, Section 6.2.5.2, “Design Basis.”

06.02.05-27

RAI 6.2.5-28:
Provide additional information on how inspection and test requirements of GDCs 41, 42 and 43 are met.

The staff requested, in RAI 6.2.5-8 that, in order to evaluate how the Combustible Gas Control system meets the inspection and test requirements of GDCs 41, 42 and 43, the applicant provide the following:

1) 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) Descriptions of how proposed inservice test criteria will be established and on what design requirements the test criteria will be based.

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), the staff requested that the applicant provide:

3) 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 the staff requested the applicant indicate the design criteria to be verified in the in-service tests and inspections. The staff requested that the applicant 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.

In a letter dated October 1, 2008, the applicant provided the following response:

1) The mechanical design features of the Containment Hydrogen Monitoring and Control System are deferred to the detailed design phase, specifically 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 are vendor specific and will be available when the equipment vendors are selected.

2) Upon receipt of Containment Hydrogen Monitoring and Control System design documents from the selected vendor (to include design and fabrication drawings, calculations, bill of materials, reports, vendor specific inservice test procedures, etc.), the specific parameters for the acceptance tests, calibrations, and inservice tests of the monitors and igniters will be defined; the tests of the acceptability and functional capability of the monitor and igniters will include monitor sensitivity and igniter function-upon-demand requirements for maintaining hydrogen in the containment atmosphere to less than 10% (by volume).

3) As part of the hydrogen igniter system submittal, the vendor's specific industrial experience and the hydrogen igniter system performance data will be required for review and evaluation to ensure that the system can achieve the governing design criteria regarding hydrogen control. As an example, the specific igniter surface temperature, voltage and current, and the test conditions will be evaluated against the projected calculated *worst-case severe accident hydrogen control needs. Thus, the description of the inservice test and inspection program will be a COL item.*

The applicant further stated that DCD Subsection 6.2.5.4 and Subsection 6.2.8 will be revised to include the following COL item:

COL 6.2(11) The COL Applicant is responsible to provide the specific inspection and test features of the containment hydrogen monitoring and control system, including for the hydrogen monitor and the hydrogen igniters, upon receipt of selected equipment vendor information.

The staff has reviewed this response and has identified that the following needs to be addressed by the applicant:

Please clarify when you expect a COL applicant to receive and provide to the NRC for review, the specific inspection and test features of the containment hydrogen monitoring and control system, including the hydrogen monitor and hydrogen igniters. That is, it is our expectation that such design detail information would be supplied with the COL application, and would be used to evaluate the design pursuant to granting the COL to the applicant. The level of detail of such design information should be sufficient to determine a review finding in the following areas:

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.

Descriptions of the proposed inservice test, and on what design requirements the test criteria will be established.

Descriptions of the design sufficient 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), such information would include performance requirements for each igniter, e.g., minimum igniter surface temperature, voltage and current.

06.02.05-28

RAI 6.2.5-28:
Provide additional information on how inspection and test requirements of GDCs 41, 42 and 43 are met.

The staff requested, in RAI 6.2.5-8 that, in order to evaluate how the Combustible Gas Control system meets the inspection and test requirements of GDCs 41, 42 and 43, the applicant provide the following:

1) 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) Descriptions of how proposed inservice test criteria will be established and on what design requirements the test criteria will be based.

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), the staff requested that the applicant provide:

3) 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 the staff requested the applicant indicate the design criteria to be verified in the in-service tests and inspections. The staff requested that the applicant 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.

In a letter dated October 1, 2008, the applicant provided the following response:

1) The mechanical design features of the Containment Hydrogen Monitoring and Control System are deferred to the detailed design phase, specifically 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 are vendor specific and will be available when the equipment vendors are selected.

2) Upon receipt of Containment Hydrogen Monitoring and Control System design documents from the selected vendor (to include design and fabrication drawings, calculations, bill of materials, reports, vendor specific inservice test procedures, etc.), the specific parameters for the acceptance tests, calibrations, and inservice tests of the monitors and igniters will be defined; the tests of the acceptability and functional capability of the monitor and igniters will include monitor sensitivity and igniter function-upon-demand requirements for maintaining hydrogen in the containment atmosphere to less than 10% (by volume).

3) As part of the hydrogen igniter system submittal, the vendor's specific industrial experience and the hydrogen igniter system performance data will be required for review and evaluation to ensure that the system can achieve the governing design criteria regarding hydrogen control. As an example, the specific igniter surface temperature, voltage and current, and the test conditions will be evaluated against the projected calculated worst-case severe accident hydrogen control needs. Thus, the description of the inservice test and inspection program will be a COL item.

The applicant further stated that DCD Subsection 6.2.5.4 and Subsection 6.2.8 will be revised to include the following COL item:

COL 6.2(11) The COL Applicant is responsible to provide the specific inspection and test features of the containment hydrogen monitoring and control system, including for the hydrogen monitor and the hydrogen igniters, upon receipt of selected equipment vendor information.

The staff has reviewed this response and has identified that the following needs to be addressed by the applicant:

Based on the intent of your letter dated 11/7,2008, titled “Transmission of COL Information Update for US-APWR Design Control Document Revision 1”, this proposed COL item would most likely be a “holder item” and thus would not be an acceptable response.

Provide the following additional information:

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.

06.02.05-29

RAI 6.2.5-29:
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.

The staff requested, in RAI 6.2.5-9 that the applicant provide a discussion of design requirements to ensure reliability, availability and capability of the hydrogen detection system.

The applicant provided the following response:

As for the MHI's understanding, the hydrogen control system is provided to mitigate the significantly beyond-design-basis accident, and there are no specific requirements for hydrogen control during the design basis accident. The challenge to the containment integrity due to hydrogen generated from the design basis accident has been evaluated negligibly small from the risk point of view. Therefore as specified in the RG1.7, Revision 3, Section C.1, the hydrogen control system is not subject to the environmental qualification requirements of 10 CFR 50.49, quality assurance requirements of Appendix B to 10 CFR Part 50, and redundancy/diversity requirements of Appendix A to 10 CFR Part 50.

Nevertheless, regarding the power supply of the hydrogen monitoring system, two non-class 1E buses are provided through cross-connection and also two back up non-class 1 E alternate ac gas turbine generators-are provided. Overall, it is concluded that the hydrogen monitoring system is designed with the capability to remain operable assuming a single failure such as a failure of one power supply.

The hydrogen detector is installed outside the containment and hence it is evaluated as not subject to the equipment survivability analysis. In addition it should be noted that the signal transmitted from the hydrogen detector is not utilized to control other system. The role of the hydrogen detector for the US-APWR is to provide supportive information for the operators' action, as discussed in the RAI Question No.06.02.05-3.

The staff has reviewed this response and has identified that the following needs to be addressed by the applicant:

The statement in the response: “The role of the hydrogen detector for the US-APWR is to provide supportive information for the operators' action, as discussed in the RAI Question No.06.02.05-3” implies that such operator actions will be developed under the severe accident management program and supplied via a COL item.

However, based on the 11/7/08 CP COL supplement letter, and actions, this proposed COL item is deleted.

In your response to RAI 6.2.5-3, you discuss the importance of accurate measurement of hydrogen concentration in containment in the management of a severe accident in the US-APWR design. In regard to this acknowledgement and notwithstanding your response to RAI 6.2.5-9, additional information is required in order for the staff to evaluate the design requirements to ensure reliability, availability and capability of the hydrogen detection system. Please provide the following design information as per RG 1.7 C2.1:

- Display and recording: further details as per item (4) of RG 1.7 C2.1
- Service Testing and Calibration: further details as per item (6) of RG 1.7 C2.1
- Human factors: Describe specific design details of the monitor that address functional requirements for the risk-informed alternatives to TMI

action plan item II.F.1, Attachment 6 in NUREG-0737, which states that hydrogen monitors are to be functioning within 30 minutes of the initiation of safety injection. (i.e., what is the time required for the H2 monitor to be functional for the US-APWR design?)

06.02.05-30

RAI 6.2.5-30:
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.

The staff requested, in RAI 6.2.5-12 that the applicant 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.

The applicant provided the following response:

The hydrogen analyzer test and design criteria, including those listed in Regulatory Guide 1.7, will be incorporated into the analyzer procurement specifications in the detailed design phase.

Following completion of fabrication, equipment acceptance, tests will be conducted with known samples, under a certified QA program, and/or witnessed by engineering representatives. Each vendor will also be required to provide operating experience on the hydrogen analyzer as part of the equipment bid submittal. Test results will be collected, checked, and evaluated in a report for submittal and will be reviewed by the Owner (Purchaser) and/or an engineering representative to verify the performance capability of the hydrogen analyzer. Equipment vendors. will be evaluated for qualifications to meet a certified Quality Assurance Program, and further consideration will be based on industrial experiences for the hydrogen analyzer. The successful vendor chosen to. provide the hydrogen analyzer will be required to provide design documents (design and fabrication drawings, calculations, bill of materials, test conditions and procedures, reports, etc to be reviewed and approved by the owner, or a representative, to verify that the design and fabrication meet the criteria specified in the procurement specifications. The analyzer equipment package, when completed, will undergo acceptance testing in the presence of engineering witnesses or under a certified QA program. This procedure will insure that the equipment is consistent with the procurement specifications.

After installation, the hydrogen analyzer design will undergo calibration tests prior to start-up. Based on industrial experience and the manufacturer's recommendation, the calibration tests will also be conducted periodically to insure that the performance capability of the hydrogen analyzer meets the design criteria.

The details of the test and calibration procedures are vendor specific and will be available after an equipment vendor is selected. DCD Subsection 14.2.12.1.64 captures the preoperational test requirements.

Based on this evaluation, more information in DCD Subsection 14.2.12.1.64 is not available or needed.

The staff has reviewed this response and has identified that the following needs to be addressed by the applicant:

In your response to RAI 6.2.5-12 you provide detail on preservice and inservice testing of the combustible gas monitor. Please include this information in Sections 6.2.5.4.1 and 6.2.5.4.2 of the DCD, which currently only discuss testing of the hydrogen ignition system.

06.02.05-31

RAI 6.2.5-31:

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.

The staff requested, in RAI 6.2.5-14 that the applicant 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.

The applicant provided the following response:

Please refer to the technical report "US-APWR Probabilistic Risk Assessment" (MUAP-07030) Chapter 15 Separate Effect Analysis. Section 15.3 of this report describes the discussion on the hydrogen generation and control, and the accident progression analyses in Subsection 15.3.3 consider 100% zirconium of the active fuel length cladding reaction as well as the remaining cladding reaction shortly after RV failure with ECCS or containment spray water spilled into the reactor cavity. In the global hydrogen burn analyses in Subsection 15.3.4 considers 100% zirconium of the active fuel length cladding reaction as the basic case, and 100% zirconium in whole in-core structures reactions as the sensitivity case.

Hydrogen generation other than zirconium-water reaction is not considered in the study because the generation rates are considered significantly slower than that from zirconium reaction. It can be therefore considered the hydrogen generated from the MCCI, etc. is negligible in terms of the discussion on the CHS effectiveness.

The staff has reviewed this response and has identified that the following needs to be addressed by the applicant:

1) Your response indicates that the assumption was made that the zirconium-water reaction was by far the primary driver for the hydrogen generation, and that all other sources of hydrogen were insignificant by comparison so that they could be disregarded, including hydrogen generated from molten core-concrete interaction (MCCI). This appears to be in contradiction to statements in Sections 15.3.3.1 and 15.3.3.3 of MUAP-07030 which talk about incorporating releases from MCCI in the evaluations. Please clarify this inconsistency.

2) In reference to RAI 6.2.5-1, please include a discussion in the analysis to be included in Tier 2, that states that hydrogen production from an inventory of hydrogen producing materials within containment was regarded as an insignificant contributor, and not assumed in the analysis.

06.02.05-32

RAI 6.2.5-32:
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.

The staff requested, in RAI 6.2.5-17 that the applicant 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.
The applicant provided the following response:

Section I.A (3), Appendix C.11.1-A of RG 1.206 discusses the ITAAC for the severe accident features, as follows.

"The design description should describe these features, and the functional arrangement ITAAC should verify that they exist. In general, the ITAAC need not include the capabilities of these features."

Thus, ITAAC for the non-safety systems with severe accident features should focus on verification of the existence (not capabilities) of the systems, components, or equipment, and the ITAAC for the severe accident features which are linked to the capabilities are not proposed in Tier 1.

DCD Tier 1, Subsection 2.11.4 will be used to confirm the adequacy of the CHS. Based on the above consideration, MHI will revise the DCD Tier 1, Subsection 2.11.4. Refer to the response to RAI No.51 question No.14.03.11-1.

Impact on DCD:

Refer to RAI No.51 Question No.14.03.11-1.

The staff has reviewed this response and has identified that the following needs to be addressed by the applicant:

1) In addition to the DCD changes cited in the RAI 14.3.4.11-1 response, revise the Tier 1 DCD to add the Tier 2 figure and include ITAAC to verify the specific location of each hydrogen igniter in containment.

2) Include additional design basis information on the hydrogen igniter system in the DCD Tier 2 as specified by RAIs 6.2.5-27 and 6.2.5-28.

06.02.05-33

RAI 6.2.5-33:
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.

The staff requested, in RAI 6.2.5-18 that the applicant 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.

The applicant provided the following response:

As per DCD section 3 Table 3.2-1, igniters for the containment hydrogen control system are classified as Equipment Class 4 and Quality Group D in accordance with RG 1.26. However, it is identified through the Level 2 PRA study for the US-APWR that the hydrogen igniters are risk significant during severe accident. Igniters are installed in a manner ensuring that they do not degrade the existing safety-related systems, including making the non-safety equipment as independent as practicable from existing safety-related systems. This will be accomplished in part, by locating the 20 igniters in open areas of the containment away from safety-related equipment.
The combustible gas control system the procurement specifications will establish measures and state the equipment compliance with 10 CFR 50.44, 10 CFR 50.34(f)(2)(ix) and GDC 5, 41, 42, 43.
Also, vendors will be pre-qualified to bid, ensuring that vendors who produce the equipment are known to use approved materials and methods. After a vendor is selected, the design will be reviewed to ensure it meets the stated criteria in procurement specifications. QA procedures will be in place for the performance of necessary audits of the vendor to ensure that the material, equipment, and services conform to the design related guidelines and procurement documents.

The staff has reviewed this response and has identified that the following needs to be addressed by the applicant:

Include the following text from your RAI response in Tier 2, Section 6.2.5.2, System Design: “Igniters are installed in a manner ensuring that they do not degrade the existing safety-related systems, including making the non-safety equipment as independent as practicable from existing safety-related systems. This will be accomplished in part, by locating the 20 igniters in open areas of the containment away from safety-related equipment."

06.02.05-34

RAI 6.2.5-34:

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.

The staff requested, in RAI 6.2.5-19 that the applicant 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.

The applicant provided the following response:

MHI agrees that the NRC's concern is true, that the load associated with the release of hydrogen generated from 100% cladding-water reaction exceeds the one associated with dead load plus 45 psig. As for the MHI's understanding, it is necessary to separately consider the design-basis accident and severe accident for this issue. The discussion provided in Section 3.8.1.3.2.2 of the DCD is based on the design-basis accident, thus 100% cladding reaction is not taken into account. The postulated condition with 100% cladding reaction is obviously significantly beyond the design-basis. The conclusion in Section 3.8.1.3.2.2 is therefore good only for the evaluation on the design-basis accidents. The US-APWR PCCV is designed based on a DBA pressure Pa of 68 psig and a corresponding design test pressure of 1.15 x Pa, hence the minimum design condition of D+45 psig is satisfied under the postulated conditions of DBA. On the other hand, Section 19.2 of the DCD describes the severe accident analyses, including the pressure load associated with the hydrogen released from 100% cladding-water reaction. Please refer to the technical report "US-APWR Probabilistic Risk Assessment" (MUAP-07030) Chapter 15 Separate Effect Analysis, in which detailed discussions on severe accident evaluations are provided. Section 15.3 of this report describes the discussion on the hydrogen generation and control, and the evaluations of the containment integrity under the hydrogen burning condition, including local burn and global burn, are described. Chapter 16 of this technical report describes the discussion on the containment ultimate pressure capability, in which the ultimate containment capability is evaluated as 216 psia. It is concluded from these evaluations that the containment integrity is sufficiently maintained against the challenge from hydrogen burn associated with 100% cladding-water reactions.

The staff has reviewed this response and has identified that the following needs to be addressed by the applicant:

The staff does not agree with MHI's position that the structural integrity of the PCCV should be evaluated with different criteria than that specified in RG 1.136 for the severe accident case.

RG 1.136 Section C(5) clearly states that severe accident loads, such as the pressure resulting from an accident that releases hydrogen generated from 100% fuel clad-metal-water reaction plus the pressure resulting from uncontrolled hydrogen burning be considered in the Factored Load Category when evaluating allowable limits from stresses and strains, when using ASME Article CC-3720.

Please provide an ASME Article CC-3720 analysis that demonstrates that containment structural integrity will be maintained in such an event, or please provide an alternate methodology, and clarify the DCD.