MITSUBISHI HEAVY INDUSTRIES, LTD.
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TOKYO, JAPAN

June 5, 2009

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Attention: Mr. Jeffrey A. Ciocco

Docket No. 52-021
MHI Ref: UAP-HF-09281

Subject: MHI's Responses to US-APWR DCD RAI No.270-1898

References: 1) "Request for Additional Information No.270-1898 Revision 1, SRP Section: 06.02.05 – Combustible Gas Control in Containment, Application Section: Tier 2 DCD 6.2.5" dated on March 9, 2009.
2) Letter MHI Ref: UAP-HF-09010 from Y. Ogata (MHI) to U.S. NRC, "Submittal of Revised RAI Responses due to the COL Information Update" dated on January 9, 2009.
3) Letter MHI Ref: UAP-HF-09198 from Y. Ogata (MHI) to U.S. NRC, "MHI's Responses to US-APWR DCD RAI No.222-1933" dated on April 23, 2009.

With this letter, Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") a document entitled "Responses to Request for Additional Information No.270-1898 Revision 1".

Enclosed are the responses to 13 RAIs contained within Reference 1.

As indicated in the enclosed materials, this document contains information that MHI considers proprietary, and therefore should be withheld from public disclosure pursuant to 10 C.F.R. § 2.390 (a)(4) as trade secrets and commercial or financial information which is privileged or confidential. A non-proprietary version of the document is also being submitted with the information identified as proprietary redacted and replaced by the designation "[ ]".

This letter includes a copy of the proprietary version (Enclosure 2), a copy of the non-proprietary version (Enclosure 3), and the Affidavit of Yoshiki Ogata (Enclosure 1) which identifies the reasons MHI respectfully requests that all materials designated as "Proprietary" in Enclosure 2 be withheld from public disclosure pursuant to 10 C.F.R. § 2.390 (a)(4).

Please contact Dr. C. Keith Paulson, Senior Technical Manager, Mitsubishi Nuclear Energy Systems, Inc. if the NRC has questions concerning any aspect of this letter. His contact information is provided below.

Sincerely,

Y. Ogata

Yoshiki Ogata,
General Manager- APWR Promoting Department
Mitsubishi Heavy Industries, LTD.

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NRO

Enclosures:

1. Affidavit of Yoshiki Ogata

2. Responses to Request for Additional Information No. 270-1898, Revision 1 (Proprietary version)

3. Responses to Request for Additional Information No. 270-1898, Revision 1 (Non-proprietary version)

CC: J. A. Ciocco
C. K. Paulson

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ENCLOSURE 1

Docket No. 52-021
MHI Ref: UAP-HF-09281

MITSUBISHI HEAVY INDUSTRIES, LTD.

AFFIDAVIT

I, Yoshiki Ogata, state as follows:

1. I am General Manager, APWR Promoting Department, of Mitsubishi Heavy Industries, LTD ("MHI"), and have been delegated the function of reviewing MHI's US-APWR documentation to determine whether it contains information that should be withheld from public disclosure pursuant to 10 C.F.R. § 2.390 (a)(4) as trade secrets and commercial or financial information which is privileged or confidential.

2. In accordance with my responsibilities, I have reviewed the enclosed document entitled "Responses to Request for Additional Information No. 270-1898, Revision 1" dated June, 2009, and have determined that portions of the document contain proprietary information that should be withheld from public disclosure. Those pages containing proprietary information are identified with the label "Proprietary" on the top of the page and the proprietary information has been bracketed with an open and closed bracket as shown here "[ ]". The first page of the document indicates that all information identified as "Proprietary" should be withheld from public disclosure pursuant to 10 C.F.R. § 2.390 (a)(4).

3. The information identified as proprietary in the enclosed document has in the past been, and will continue to be, held in confidence by MHI and its disclosure outside the company is limited to regulatory bodies, customers and potential customers, and their agents, suppliers, and licensees, and others with a legitimate need for the information, and is always subject to suitable measures to protect it from unauthorized use or disclosure.

4. The basis for holding the referenced information confidential is that it describes the unique design and methodology developed by MHI for performing the design of the US-APWR reactor.

5. The referenced information is being furnished to the Nuclear Regulatory Commission ("NRC") in confidence and solely for the purpose of information to the NRC staff.

6. The referenced information is not available in public sources and could not be gathered readily from other publicly available information. Other than through the provisions in paragraph 3 above, MHI knows of no way the information could be lawfully acquired by organizations or individuals outside of MHI.

7. Public disclosure of the referenced information would assist competitors of MHI in their design of new nuclear power plants without incurring the costs or risks associated with the design of the subject systems. Therefore, disclosure of the information contained in the referenced document would have the following negative impacts on the competitive position of MHI in the U.S. nuclear plant market:

    A. Loss of competitive advantage due to the costs associated with development of methodology related to the analysis.

B. Loss of competitive advantage of the US-APWR created by benefits of modeling information.

I declare under penalty of perjury that the foregoing affidavit and the matters stated therein are true and correct to the best of my knowledge, information and belief.

Executed on this 5th day of June, 2009.

Y. Ogata

Yoshiki Ogata,
General Manager- APWR Promoting Department
Mitsubishi Heavy Industries, LTD.

Enclosure 3

UAP-HF-09281
Docket Number 52-021

Responses to Request for Additional Information No. 270-1898, Revision 1

June, 2009
(Non-Proprietary)

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

6/5/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.: **NO. 270-1898 REVISION 1**

SRP SECTION: **06.02.05 – Combustible Gas Control in Containment**

APPLICATION SECTION: **6.2.5**

DATE OF RAI ISSUE: **3/9/2009**

QUESTION NO.: 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

ANSWER:

1) MHI would like to propose changing the description of second paragraph of DCD Subsection 6.2.5.3 and 6.2.9 as follows:

6.2.5.3 Design Evaluation

...

Beyond-design-basis evaluations documented in Chapter 19 include a combustible gas release within containment corresponding to the equivalent amount of combustible gas that would be generated from a 100% fuel-clad coolant reaction, uniformly distributed. As discussed in Section B of Revision 3 of RG 1.7 (Ref. 6.2-29), these Chapter 19 evaluations are intended to show that hydrogen concentrations do not exceed 10 volume percent (10 vol.%) and that the structural integrity of the containment pressure boundary is maintained. <u>Detailed evaluation for hydrogen generation and control is provided in the technical report "US-APWR Probabilistic Risk Assessment" Section 15.3 (Ref. 6.2-35).</u>

6.2.9 References

...

<u>6.2-35 Tanaka, F., et al., US-APWR Probabilistic Risk Assessment, MUAP-07030 Rev.1, Mitsubishi Heavy Industries, September 2008.</u>

MHI understands the intention of the NRC staff for this RAI. MHI however considers it is better not to duplicate one description in multiple documents; instead one document should reference the description provided in another document in order to avoid confusion during the review process. Official review for the DCD Ch. 19 has been carried out on this manner.

2) The hydrogen concentrations of each node which have been cut off are shown in Figures 6.2.5-22-1 to 6.2.5-22-4.

Impact on DCD

DCD will be revised in accordance with this RAI answer to question 1).

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on current PRA evaluation result from this RAI. PRA technical report (MUAP-07030) will be revised to address this RAI answer to question 2).

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

6/5/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.:	**NO. 270-1898 REVISION 1**
SRP SECTION:	**06.02.05 – Combustible Gas Control in Containment**
APPLICATION SECTION:	**6.2.5**
DATE OF RAI ISSUE:	**3/9/2009**

QUESTION NO.: 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).

ANSWER:

1) As answered to RAI 6.2.5-22 above, MHI considers it is better not to duplicate one description in multiple documents; instead one document should reference the description provided in another document in order to avoid confusion during the review process. MHI would like to propose changing the description of DCD in accordance with this consideration. Please see the answer to RAI 6.2.5-22.

2) MHI has analyzed a scenario of transient with depressurization valve release (TMLD_DP) as described in Chapter 15 of the PRA technical report (MUAP-07030); this is exactly an analysis for the efficiency of high point vents. MHI simulated the containment condition under this high point venting situation by utilizing GOTHIC code, and obtained the analytical result that containment atmosphere is well mixed. This analysis result is the justification to assure the atmosphere mixing.

3) MHI additionally analyzed LOCA scenarios to model DBA situation by utilizing MAAP code. In order to broadly address various LOCA sequences, two different break sizes were evaluated. As assumed in the safety analysis described in Chapter 15 of the DCD, LOCA followed by loss of offsite power is considered. Accordingly, a few minutes delay to start safety injection and containment spray was considered in the calculations. Same as the safety analysis, operations of two SI pumps and two CS pumps are assumed.

Evaluated sequences

4) After having the clarification telephone conference on 6 April 2009, MHI understood the intention of the NRC staff was to review the scenario without containment spray operation. The analysis results for several severe accident scenarios without containment spray are described in Chapter 14 of the PRA technical report (MUAP-07030), such as sequence AP001, AP002, AP101, AP102, AP103, AP201, AP202 and AP203. In these calculations, evaluation for hydrogen concentration is also included and it can be observed that in any sequences the hydrogen concentration is below 10%.

Impact on DCD

DCD will be revised in accordance with this RAI answer to question 1).

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

6/5/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.:	**NO. 270-1898 REVISION 1**
SRP SECTION:	**06.02.05 – Combustible Gas Control in Containment**
APPLICATION SECTION:	**6.2.5**
DATE OF RAI ISSUE:	**3/9/2009**

QUESTION NO.: 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 USAPWR 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.

ANSWER:

Regarding the issue of proposal to delete COL item 19.3(6) in a letter dated 7 November 2008 (MHI Ref: UAP-HF-08259), the treatment is currently under discussion among the NRC Ch. 19 review staff, MNES and MHI. MHI understands the position of the NRC staff, and has no objection to withdraw the proposal to delete COL item 19.3(6). MHI would like to revise the description of COL item 19.3(6) and the resolution on this issue will be transmitted to the NRC separately.

The detailed procedure how to manage the containment pressure and the hydrogen concentration will be developed as the COL action in accordance with the revised COL item 19.3(6).

MHI would also like to change the description of DCD Subsection 19.2.5 as following:

19.2.5 Accident Management

...

(3) To maintain containment integrity as long as possible

...

- ......
- Accident management of prevention of early containment failure is through prevention of containment bypass, HPME and hydrogen detonation. RCS depressurization is in order for prevention of HPME and temperature-induced SGTR. When core damage is detected, severe accident dedicated depressurization valve is opened and if necessary safety depressurization valve is opened. In case water supply to SG is available, main

steam depressurization valve is opened to enhance primary system cooling and depressurization if needed. Water supply to SG is recovered or controlled to avoid FP release due to temperature induced SGTR through secondary system, also to depressurize RCS. Main feedwater system or emergency feedwater system are employed for this function and operation is required when SG water level decreases below a criterion if available. Combustible gas control is in order to prevent containment failure especially due to hydrogen detonation. Although the combustible gas control is automatically achieved by hydrogen ignition system, in case CSS fails and containment vessel atmosphere is kept inerted for certain duration, CSS recovery or operation of alternate containment cooling may lead containment vessel atmosphere to combustible condition under high hydrogen concentration. In such case containment depressurization is suspended at a relatively high containment pressure. It is widely known that the low inert limit of steam concentration is approximately 55% and the low flammability limit of hydrogen concentration is approximately 4%. Hydrogen impact when depressurizing containment is evaluated and a material, such as a map of hydrogen concentration vs. containment pressure to show if hydrogen burn is safe or potential danger, is prepared to support the containment depressurization operation. MCR alarm for hydrogen concentration is also provided through the containment hydrogen monitoring system when the hydrogen concentration reaches 4% and 8%. The control room operators are required to carefully monitor the condition of containment. ~~This operation is taken if combustible gas concentration is more than certain value before or when containment depressurization is in operation.~~

Impact on DCD

DCD will be revised in accordance with this RAI answer.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

6/5/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.:	**NO. 270-1898 REVISION 1**
SRP SECTION:	**06.02.05 – Combustible Gas Control in Containment**
APPLICATION SECTION:	**6.2.5**
DATE OF RAI ISSUE:	**3/9/2009**

QUESTION NO.: 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.

ANSWER:

1) The design description in Tier 1 Subsection 2.11.4.1 will be revised to add the hydrogen concentration alarm to the "Location and Functional Arrangement" description, which is subject to ITAAC Item 1 in Table 2.11.4-1. This change is included in the response to Question No.14.03.11-18 and No.14.03.11-24, RAI No.222-1933 Revision 1.

2) Please see the answer to RAI 6.2.5-24, which covers the response to this RAI as well.

Impact on DCD

1) The impact on DCD Tier 1 Subsection 2.11.4 has been provided. Please see "Impact on DCD" of Question No. 14.03.11-18, RAI No.222-1933 Revision 1 transmitted by UAP-HF-09198 dated 04/23/2009.

2) DCD will be revised in accordance with this RAI answer.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

6/5/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.:	**NO. 270-1898 REVISION 1**
SRP SECTION:	**06.02.05 – Combustible Gas Control in Containment**
APPLICATION SECTION:	**6.2.5**
DATE OF RAI ISSUE:	**3/9/2009**

QUESTION NO.: 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."

ANSWER:

MHI would like to propose changing the description of DCD Subsection 6.2.5.2 as follows:

6.2.5.2 System Design

...

The hydrogen monitoring and control system is supplied by the non-Class 1E P1 and P2 power system, with alternate power capability. P1 and P2 buses are capable of cross-connection, providing power to both motor control centers (MCCs). Both P1 and P2 buses are backed by non-Class 1E alternate ac gas turbine generators. The power distribution to the monitor and igniters is designed to minimize the impact of the loss of any single power source. As noted above, the containment hydrogen concentration is indicated in the MCR. This system may also be actuated manually.

The containment hydrogen monitoring and control system 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 containment hydrogen monitoring and control system in order to maintain the containment integrity during postulated severe accidents, it is designed satisfying the plant HCLPF (high confidence of low probability failure) is evaluated more than 0.5G.

The containment hydrogen monitor and igniters are designed to function in a severe accident environment. Chapter 19, Subsection 19.2.3.3.7 describes equipment survivability in severe accident conditions inside the containment.

...

Impact on DCD

DCD will be revised in accordance with this RAI answer.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

6/5/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.:	**NO. 270-1898 REVISION 1**
SRP SECTION:	**06.02.05 – Combustible Gas Control in Containment**
APPLICATION SECTION:	**6.2.5**
DATE OF RAI ISSUE:	**3/9/2009**

QUESTION NO.: 6.2.5-27

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.

ANSWER:

In a letter, UAP-HF-09010 dated on January 9, 2009, MHI had transmitted the revised response to Question No. 06.02.05-8, as follows.

1) The Containment Hydrogen Monitoring and Control System are designed and located so that they are accessible for inspection and testing periodically. The hydrogen monitor can be inspected during normal power operation, since it is located outside containment. And the hydrogen monitor provides a MCR indication and as such provides continuous testability. On the other hand, the hydrogen igniters are located inside containment, so that it can be inspected and tested by energizing during refueling outage. ~~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) The test criteria of system function are based on the requirement of RG 1.7 Rev.3 and the performance requirement of this system. The specific inservice test, inspection and calibration of system equipment will be defined, upon receipt of this system design documents from the selected vendor. ~~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) The performance requirements for the hydrogen igniters are minimum surface temperature and auto initiation by an ECCS actuation signal. The design criterion of surface temperature is higher than 1500 deg F to achieve spontaneous ignition of hydrogen during severe accident conditions. ~~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 DCD Subsection 6.2.5.4 and Table 6.2.5-1 will be revised to reflect above-mentioned information. ~~Thus, the description of the inservice test and inspection program will be a COL item.~~

MHI think the revised RAI response to Question No.06.02.05-8 is sufficient to this question, Question No.06.02.05-27.
Furthermore, MHI revise the response 2), as follows:

2) The test criteria of system function are based on the requirement of RG 1.7 Rev.3 and the performance requirement of this system. ~~The specific inservice test, inspection and calibration of system equipment will be defined, upon receipt of this system design documents from the selected vendor.~~

Impact on DCD

The impact on DCD Subsection 6.2.5.4 and Table 6.2.5-1 has been provided. Please see "Impact on DCD" of Question No. 06.02.05-8, RAI No.62 Revision 0 transmitted by UAP-HF-09010 dated 01/09/2009.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

6/5/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.:	**NO. 270-1898 REVISION 1**
SRP SECTION:	**06.02.05 – Combustible Gas Control in Containment**
APPLICATION SECTION:	**6.2.5**
DATE OF RAI ISSUE:	**3/9/2009**

QUESTION NO.: 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 inservice 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.

ANSWER:

The response to RAI No.62, Question No. 06.02.05-8 had been revised and transmitted by a letter, UAP-HF-09010 dated on January 9, 2009.
Please see "ANSWER" of Question No. 06.02.05-27.

Impact on DCD

Please see "Impact on DCD" of Question No. 06.02.05-27.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

6/5/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.:	**NO. 270-1898 REVISION 1**
SRP SECTION:	**06.02.05 – Combustible Gas Control in Containment**
APPLICATION SECTION:	**6.2.5**
DATE OF RAI ISSUE:	**3/9/2009**

QUESTION NO.: 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 1E 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 USAPWR 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?)

ANSWER:

As for the issue of deleting COL item 19.3(6) and development of the application of the hydrogen monitoring system, please see the answer to the RAI 6.2.5-24.

Regarding the additional design information, MHI would like to propose changing the description of DCD Subsection 6.2.5.2 as follows:

6.2.5.2 System Design

...

A diagram of the containment hydrogen monitoring and control system is presented in Figure 6.2.5-1. Containment hydrogen monitoring and control design parameters are found in Table 6.2.5-1.

<u>Hydrogen monitoring system provides an ability to monitor and record the containment hydrogen concentration continuously at least 24 hours in the MCR. Service testing and calibration of the hydrogen monitoring system is always available because this system is located at outside of the containment. Monitoring and recoding are functional within 90 minutes after the initiation of safety injection with satisfying the requirements described in Revision 3 of RG 1.7 C.2.1 (Ref. 6.2-29).</u>

The hydrogen monitoring and control system is supplied by the non-Class 1E P1 and P2 power system, with alternate power capability. P1 and P2 buses are capable of cross-connection, providing power to both motor control centers (MCCs). Both P1 and P2 buses are backed by non-Class 1E alternate ac gas turbine generators. The power distribution to the monitor and igniters is designed to minimize the impact of the loss of any single power source. As noted above, the containment hydrogen concentration is indicated in the MCR. This system may also be actuated manually.

...

Impact on DCD

DCD will be revised in accordance with this RAI answer.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

6/5/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.:	**NO. 270-1898 REVISION 1**
SRP SECTION:	**06.02.05 – Combustible Gas Control in Containment**
APPLICATION SECTION:	**6.2.5**
DATE OF RAI ISSUE:	**3/9/2009**

QUESTION NO.: 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.

ANSWER:

DCD Subsection 6.2.5.4.1 will be revised to reflect the response to RAI No.62, Question No. 06.02.05-12.

Impact on DCD

DCD Subsection 6.2.5.4.1 will be revised as follows:

6.2.5.4.1 Preservice Testing

Chapter 14 describes the initial test program, which includes the pre-operational and startup testing.

Pre-operational testing of the hydrogen monitoring system is performed either before or after installation, but prior to plant startup to verify performance. The hydrogen monitor test and design criteria, including those listed in Regulatory Guide 1.7, are incorporated into the hydrogen monitor procurement specifications. Following completion of fabrication, the hydrogen monitor acceptance tests are conducted with known samples. The hydrogen monitor is required to be reflected operating experience on the hydrogen monitor. Test results are collected, checked, and evaluated in a report and are reviewed to verify the performance capability of the hydrogen monitor. The design documents of hydrogen monitor (design and fabrication drawings, calculations, bill of materials, test conditions and procedures, reports, etc.) are reviewed to verify that the design and fabrication meet the criteria specified in the procurement specifications. The hydrogen monitor, when completed, undergoes acceptance testing. This procedure insures that the hydrogen monitor is consistent with the design criteria. After installation, the hydrogen monitor design undergoes calibration tests prior to start-up. Based on industrial experience and the manufacturer's recommendation, the calibration tests are also conducted periodically to insure that the performance capability of the hydrogen monitor meets the design criteria.

Pre-operational testing and inspection of the hydrogen ignition system is performed after installation and prior to plant startup to verify operability of the hydrogen igniters. Verification of the hydrogen igniter positions is also performed. This verification confirms that the surface temperature of the hydrogen igniters meets or exceeds the hydrogen ignition temperature specified in Table 6.2.5-1, thereby ensuring ignition of hydrogen concentrations above the flammability limit.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

6/5/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.:	**NO. 270-1898 REVISION 1**
SRP SECTION:	**06.02.05 – Combustible Gas Control in Containment**
APPLICATION SECTION:	**6.2.5**
DATE OF RAI ISSUE:	**3/9/2009**

QUESTION NO.: 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.

ANSWER:

1) The response of RAI 6.2.5-14 about the MCCI is error in writing. The analysis in Subsection 15.3.3 of the MUAP-07030 considered hydrogen generation from MCCI. Therefore the amended response of RAI 6.2.5-14 is following:

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

2) As answered to the RAI 6.2.5-22, MHI would like to add reference to the DCD, but not to duplicate one description in multiple documents. Please see the answer to RAI 6.2.5-22.

Impact on DCD

DCD will be revised in accordance with this RAI answer to question 2).

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

6/5/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.:	**NO. 270-1898 REVISION 1**
SRP SECTION:	**06.02.05 – Combustible Gas Control in Containment**
APPLICATION SECTION:	**6.2.5**
DATE OF RAI ISSUE:	**3/9/2009**

QUESTION NO.: 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.

ANSWER:

MHI will add new DCD Tier 1 Figure 2.11.4-1, based on Tier 2 Figure 6.2.5-1. As requested, an ITAAC to verify the location of the hydrogen igniters will be added to Table 2.11.4-1. This change is included in the response to Question No.14.03.11-18, RAI No.222-1933 Revision 1. Furthermore, DCD Tier 1 Subsection 2.11.4 is included other changes based on the response to Question No.14.03.11-24 and 25, RAI No.222-1933 Revision 1.

Impact on DCD

The impact on DCD Tier 1 Subsection 2.11.4 has been provided. Please see "Impact on DCD" of Question No. 14.03.11-18, RAI No.222-1933 Revision 1 transmitted by UAP-HF-09198 dated 04/23/2009.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

6/5/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.:	**NO. 270-1898 REVISION 1**
SRP SECTION:	**06.02.05 – Combustible Gas Control in Containment**
APPLICATION SECTION:	**6.2.5**
DATE OF RAI ISSUE:	**3/9/2009**

QUESTION NO.: 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 USAPWR 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."

ANSWER:

DCD Subsection 6.2.5.2 will be revised to reflect the response to RAI No.62, Question No. 06.02.05-18.

Impact on DCD

DCD Subsection 6.2.5.2 will be revised as follows:

The twenty hydrogen igniters are strategically located around the containment: one near the PRT, one in the upper area of the pressurizer subcompartment, one in the lower area of the pressurizer subcompartment, four in the SG/reactor coolant loop subcompartment (one in each subcompartment), four in the 2nd floor of the containment, four in the 3rd floor of the containment and five in the containment dome (near the top of each SG and pressurizer subcompartments). The igniters are located a sufficient distance from large equipment, ceilings, and walls to promote the efficient combustion of hydrogen. A drip shield is provided to protect the igniter from falling water (i.e., containment condensation or spray). The location and operation of hydrogen igniters does not affect the ability to monitor containment hydrogen concentration during severe accidents, or test conditions.

<u>The hydrogen 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.</u>

The containment hydrogen monitor is of a type and manufacture widely used in commercial nuclear power plants currently licensed by the NRC. The containment hydrogen monitoring equipment is regularly calibrated and the components verified operable, as required by the plant surveillance test program. The containment hydrogen monitor located outside of the containment analyzes the hydrogen concentration in the MCR after the containment isolation valves of the RMS containment air sampling line are manually opened.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

6/5/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.:	**NO. 270-1898 REVISION 1**
SRP SECTION:	**06.02.05 – Combustible Gas Control in Containment**
APPLICATION SECTION:	**6.2.5**
DATE OF RAI ISSUE:	**3/9/2009**

QUESTION NO.: 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 USAPWR 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.

ANSWER:

According to RG 1.136 Section C(5), MHI understands that it is necessary to evaluate that the containment maintains integrity to the following load:

D + Pg1 + [Pg2 or Pg3] where

D = Dead load

Pg1 = Pressure resulting from an accident that releases hydrogen generated from 100% fuel clad metal-water reaction

Pg2 = Pressure resulting from uncontrolled hydrogen burning

Pg3 = Pressure resulting from post-accident inerting, assuming carbon dioxide is the inerting agent

For the US-APWR containment design, the horizontal stress caused by D is calculated based on the global finite element model of PCCV and the maximum value of horizontal compressive stress 57.7 psi occurs at the point fixed to basemat. This stress is converted as the equivalent internal pressure as follows,

P_D = 57.7 (psi) x t / Din = 3.4 (psi)

P_D = Equivalent internal pressure converted from the stress caused by D

t = Wall thickness of PCCV (4" - 4')

Din = Inner radius of PCCV (74" - 7)

Pressure related to hydrogen generation and control is evaluated in Chapter 15 of the PRA technical report (MUAP-07030). Referred to Subsection 15.3.4.3 of the PRA technical report, Pg1 and Pg2 are evaluated as 46.7 psia and 127 psia, respectively. The US-APWR design does not adopt post-accident inerting as the hydrogen control, and hence Pg3 is ignored.

Containment pressure due to hydrogen generation and control can be evaluated as:

Before uncontrolled burn: D + Pg1 = P_D+ Pg1 = 50.1 pisa

After uncontrolled burn: D + Pg2 = D + Pg2 = P_D+ Pg2 = 130.4 pisa

These loads are less than the containment ultimate pressure of 216 psia. Accordingly it is confirmed that containment structural integrity is maintained from the challenge caused by hydrogen generation and control.

Impact on DCD

DCD Subsection 19.2.4.1 will be revised as follows:

19.2.4.1 Evaluation of the Containment Ultimate Capacity

...

Analysis result

This analysis is limited on the static pressure load by slow pressurization and the dynamic pressure load due, for example to violent hydrogen detonation, is not considered.

The ultimate pressure is predicted by summation of each multiplication of the cross sectional area and yielding stress of rebar, tendon, and liner plate. It is considered a very conservative assumption to apply the yielding stress of each material to predict ultimate pressure. In terms of the material property of carbon steel, there is no significant deterioration on strength for temperatures around 400°F~600°F. It is therefore a conservative assumption even though the temperature dependency is neglected. In addition, tendon and rebar are embedded in concrete and thus not influenced greatly by the surrounding temperature due to lower thermal conductivity of concrete. These considerations indicate that the ultimate pressure is 216 psia (201 psig).

According to RG 1.136 Section C(5), it is necessary to evaluate that the containment maintains integrity to the following load:

D + Pg1 + [Pg2 or Pg3] where

D = Dead load

Pg1 = Pressure resulting from an accident that releases hydrogen generated from 100% fuel clad metal-water reaction

Pg2 = Pressure resulting from uncontrolled hydrogen burning

Pg3 = Pressure resulting from post-accident inerting, assuming carbon dioxide is the inerting agent

For the US-APWR containment design, the horizontal stress caused by D is calculated based on the global finite element model of PCCV and the maximum value of horizontal compressive stress 57.7 psi occurs at the point fixed to basemat. This stress is converted as the equivalent internal pressure as follows,

P_D = 57.7 (psi) x t / Din = 3.4 (psi)

P_D = Equivalent internal pressure converted from the stress caused by D

t = Wall thickness of PCCV (4" - 4')

Din = Inner radius of PCCV (74" - 7)

Pressure related to hydrogen generation and control is evaluated in the US-APWR PRA report (Reference 19.2-69). Referred to the PRA report, Pg1 and Pg2 are evaluated as 46.7 psia and 127 psia, respectively. The US-APWR design does not adopt post-accident inerting as the hydrogen control, and hence Pg3 is ignored.

Containment pressure due to hydrogen generation and control can be evaluated as:

Before uncontrolled burn: D + Pg1 = P_D+ Pg1 = 50.1 pisa

After uncontrolled burn: D + Pg2 = P_D+ Pg2 = 130.4 pisa

These loads are less than the containment ultimate pressure of 216 psia. Accordingly it is confirmed that containment structural integrity is maintained from the challenge caused by hydrogen generation and control.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.