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February 4, 2009

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

Attention: Mr. Jeffery A. Ciocco

Docket No. 52-021
MHI Ref: UAP-HF-09038

Subject: MHI's Response to US-APWR DCD RAI No. 152-1642, RAI No. 153-1646, and RAI No. 154-1643

References: 1) "Request for Additional Information No. 152-1642 Revision 0, SRP Section: 03.05.01.02 – Internally Generated Missiles (Inside Containment), Application Section: 3.5.1.2," dated 1/12/2009.
2) "Request for Additional Information No. 153-1646 Revision 0, SRP Section: 03.05.02 – Structures Systems and Components To Be Protected From Externally-Generated Missiles, Application Section: 3.5.2," dated 1/12/2009.
3) "Request for Additional Information No. 154-1643 Revision 0, SRP Section: 03.05.01.04 – Missiles Generated By Tornadoes and Extreme Winds, Application Section: 3.5.1.4," dated 1/12/2009.

With this letter, Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") documents entitled "Response to Request for Additional Information No. 152-1642 Revision 0," "Response to Request for Additional Information No. 153-1646 Revision 0," and "Response to Request for Additional Information No. 154-1643 Revision 0."

Enclosed are the responses to 3 RAIs contained within Reference 1, 1 RAI contained within Reference 2, and 5 RAIs contained within Reference 3.

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

Sincerely,

Y. Ogata

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

1. Response to Request for Additional Information No. 152-1642, Revision 0
2. Response to Request for Additional Information No. 153-1646, Revision 0
3. Response to Request for Additional Information No. 154-1643, Revision 0

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NRO

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

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Docket No. 52-021
MHI Ref: UAP-HF-09038

Enclosure 1

UAP-HF-09038
Docket No. 52-021

Response to Request for Additional Information No. 152-1642,
Revision 0

February, 2009

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

2/04/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 152-1642 REVISION 0**
SRP SECTION:	**03.05.01.02 – Internally Generated Missiles (Inside Containment)**
APPLICATION SECTION:	**03.05.01.02**
DATE OF RAI ISSUE:	**01/12/09**

QUESTION NO. : RAI 3.5.1.2-01

In Section 3.5.1.2.2.1 of the US-APWR DCD Tier 2, Revision 1, Mitsubishi refers to Section 3.5.1.1 for discussion of its rationale to exclude certain types of equipment from consideration as credible missile sources inside the containment. For example, missiles originating valves, threaded connections and piping in high energy systems would not be credible due to ASME code criteria that control quality from production through operation, material characteristics, and in-service inspections. Qualitative discussions are also used to exclude other types of equipment (e.g. Components including missiles originating from the reactor vessel, steam generator, reactor coolant pump pressurizer, valves and piping, within the reactor coolant pressure boundary gravitational missiles such as falling objects resulting from non-seismic SSCs during a seismic event, secondary missiles, and unsecured maintenance equipment) from consideration as credible missile sources. However, Mitsubishi has not provided the analysis to demonstrate that these missiles are of insufficient energy to cause unacceptable impact or to cause unacceptable damage. Also, it is not clear to the staff whether Mitsubishi has followed the guidance described in SRP 3.5.1.2 for probabilistic analyses to determine which missiles may be non-credible by demonstrating that the event is not statistically significant if the product of the probability of missile occurrence, probability of impact on a significant target, and probability of significant damage is less than 1 x 10-7 per year.

Where the Tier 2 DCD has excluded equipment items from consideration as credible missile sources based on design features and other qualitative considerations, demonstrate how these design features and qualitative considerations would ensure a level of protection from missiles that is equivalent to the probability criteria described in SRP 3.5.1.2 , Section II, "SRP Acceptance Criteria," Item 1. Include this information in the DCD and provide a markup in your response.

ANSWER:

DCD Subsection 3.5.1.2 is to be revised in Revision 2 to reflect that for certain SSCs postulated as capable of generating missiles, the probability of missile occurrence (P_1), the product of the probability of missile occurrence and probability of missile impact ($P_1 \times P_2$), or the combined product of the probability of missile occurrence, probability of missile impact, and probability of

significant damage ($P_1 \times P_2 \times P_3$) demonstrate through probabilistic analyses that the events are not statistically significant.

Impact on DCD

DCD Revision 2 will incorporate the following changes:

- DCD Tier 2, Subsections 3.5.1.1 and 3.5.1.2 are to be re-formatted during DCD Revision 2 as part of the response to RAI 127-1641, Question 3.5.1.1-01. Refer to Response to Request for Additional Information RAI 127-1641, Question 3.5.1.1-01, for changes to Subsection 3.5.1.2 that are applicable to this response for RAI 152-1642, Question 3.5.1.2-01.

Impact on COLA

There is no impact on COLA.

Impact on PRA

There is no impact on PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

2/04/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.: **NO. 152-1642 REVISION 0**

SRP SECTION: **03.05.01.02 – Internally Generated Missiles (Inside Containment)**

APPLICATION SECTION: **03.05.01.02**

DATE OF RAI ISSUE: **01/12/09**

QUESTION NO. : RAI 3.5.1.2-02

In US-APWR DCD Tier 2, Revision 1 Section 3.5.1.2.2.3, Mitsubishi describes two credible sources (items containing high-energy fluids and high-speed rotating equipment) of internally generated missiles inside containment. Items containing high-energy fluids are dismissed as a credible source of an internally generated missile, given that all high-energy systems within the prestressed concrete containment vessel (PCCV) comply with ASME Code, Section III. Reference is made to a few non safety-related, high-speed rotating equipment items that remain as credible sources of internally generated missiles inside containment. However, information provided in the US-APWR DCD Tier 2, Revision 1 does not provide a specific listing of the non safety-related, high-speed rotating equipments items located inside containment that may be the source of credible missiles, or potential damage to or failure of SSCs important to safety as a result of missile impingement. Further, the US-APWR DCD Tier 2, Revision 1 does not describe the specific missile protection capability employed for each of these potential missiles. This information is needed so the staff can complete the review activities described in Section III, Item 2 of Standard Review Plan (SRP) 3.5.1.2.

Therefore, for the non safety-related, high-speed rotating equipment items that remain as credible sources of internally-generated missiles, provide the following information:

- the specific equipment items that represent sources for credible missiles,
- potential damage to or failure of SSCs important to safety as a result of missile impingement, and
- missile protection capability.

Include this information in the DCD and provide a markup in your response.

ANSWER:

DCD Tier 2, Subsection 3.5.1.2.2.3 is to be re-formatted in Subsection 3.5.1.2 during DCD Revision 2 as part of the response to RAI 127-1641, Question 3.5.1.1-01. The re-formatted Subsection 3.5.1.2.2 concludes that when considering both probability of occurrence and

probability of impact, the product of $P_1 \times P_2$ is less than 10^{-7} and therefore high-speed rotating equipment are not credible missile sources. No additional information is necessary for the protection against missile generation inside the containment, including the possibility of missile occurrence from non safety-related, high-speed rotating equipment items.

Impact on DCD

DCD Revision 2 will incorporate the following changes:

- DCD Tier 2, Subsections 3.5.1.1 and 3.5.1.2 are to be re-formatted during DCD Revision 2 as part of the response to RAI 127-1641, Question 3.5.1.1-01. Refer to Response to Request for Additional Information RAI 127-1641, Question 3.5.1.1-01, for changes to Subsection 3.5.1.2 that are applicable to this response for RAI 152-1642, Question 3.5.1.2-02.

Impact on COLA

There is no impact on COLA.

Impact on PRA

There is no impact on PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

2/04/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.: **NO. 152-1642 REVISION 0**

SRP SECTION: **03.05.01.02 – Internally Generated Missiles (Inside Containment)**

APPLICATION SECTION: **03.05.01.02**

DATE OF RAI ISSUE: **01/12/09**

QUESTION NO. : RAI 3.5.1.2-03

10 CFR 52.47(b) (1) requires that a DC application contain the proposed inspections, tests, analyses, and acceptance criteria (ITAAC) that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, a plant that incorporates the design certification is built and will operate in accordance with the design certification, the provisions of the Atomic Energy Act, and the NRC's regulations.

In US-APWR DCD Tier 2, Revision 1, Section 3.5.1.2, Mitsubishi refers to Section 3.5.1.1 for discussion of its approach to identify potential missiles, determine the statistical significance of potential missiles, and provide measures for SSCs requiring protection against the effects of missiles inside containment. However, DCD Tier 1 Chapter 2.0, "Design Descriptions and ITAAC," does not contain an ITAAC to verify that SSCs inside containment are designed and constructed in accordance with the requirements as described in DCD Tier 2 Section 3.5.1.2 to prevent or mitigate the effects of internally generated missiles inside containment.

Therefore, provide an ITAAC that requires COL applicant to perform a walk-down of the SSCs to ensure that SSCs described in the above cited section are protected from internally generated missiles (inside containment) in accordance with the requirements as described in DCD Tier 2 Section 3.5.1.2. Include this information in the DCD and provide a markup in your response.

ANSWER:

The response to RAI 127-1641, Question 3.5.1.1-02 commits to add discussion during Revision 2 of DCD Tier 1, Subsection 2.2.2.5, regarding protection of safety-related SSCs against credible missiles from internal sources inside and outside the containment, and to provide an ITAAC in DCD Tier 1, Table 2.2-4, to verify that SSCs inside and outside the containment are protected from credible missiles. Refer to RAI 127-1641, Question 3.5.1.1-02, for implementation of the answer to this RAI Question 3.5.1.2-03.

Impact on DCD

DCD Revision 2 will incorporate the following change:

- Applicable changes to DCD Tier 1, Subsection 2.2.2.5 and Table 2.2-4 are included for DCD Revision 2 as part of the response to RAI 127-1641, Question 3.5.1.1-02. ITAAC requirements and acceptance criteria for SSCs will require missile protection from any credible internal missiles inside and outside the containment.

Impact on COLA

There is no impact on COLA.

Impact on PRA

There is no impact on PRA.

This completes MHI's responses to the NRC's questions.

Docket No. 52-021
MHI Ref: UAP-HF-09038

Enclosure 2

UAP-HF-09038
Docket No. 52-021

Response to Request for Additional Information No. 153-1646,
Revision 0

February, 2009

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

2/04/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.: **NO. 153-1646 REVISION 0**

SRP SECTION: **03.05.02 – Structures Systems and Components To Be Protected From Externally-Generated Missiles**

APPLICATION SECTION: **03.05.02**

DATE OF RAI ISSUE: **01/12/09**

QUESTION NO. : RAI 3.5.2-01

DCD Tier 2, Revision 1, Section 3.5.2 states that evaluations of missile impact on openings in exterior walls are evaluated on a case-by-case basis. However, Mitsubishi does not include a COL action item in DCD Tier 2, Revision 1, Table 1.8.2 to require COL applicant to conduct evaluations of missile impact on openings in exterior walls. Therefore, revise DCD Tier 2, Revision 1, Table 1.8.2, to include a COL action item that requires the COL applicant that references the US-APWR design certification to evaluate effects of externally generated missile impact on openings in exterior walls. Include this information in the DCD and provide a markup in your response.

ANSWER:

Case-by-case evaluations of missile impacts on openings in exterior walls include consideration of the arrangement of equipment in the vicinity of such openings. As stated in Subsection 3.5.1.4, these evaluations are to assure that if a missile is postulated as passing through the opening, it would not prevent the safe shutdown of the plant. To clarify this interface, the statement in DCD Subsection 3.5.2 will be changed to reference Subsection 3.5.1.4 for evaluation of missile impact on openings through exterior walls. The statement in DCD Subsection 3.5.1.4 will also be clarified that a missile would not result in an offsite release exceeding the limits defined in 10 CFR 100 (Reference 3.5-2).

The COL Applicant is not responsible for evaluating the effects of externally generated missile impact on openings in exterior walls within standard plant structures. The COL Applicant is responsible only for site-specific design of seismic Category I structures in accordance with the requirements of Chapter 3, which includes consideration of the effects of externally generated missile impact on openings in Applicant-designed seismic Category I structures. No COL information item is therefore applicable for any additional design activity.

Impact on DCD

See Attachment 1 for a mark-up of DCD Tier 2, Section 3.5, Revision 2, changes to be incorporated:

- Change the first sentence in the fourth paragraph of Subsection 3.5.1.4 to:

"Openings through the exterior walls of the seismic Category I structures, and the location of equipment in the vicinity of such openings, are arranged so that a missile passing through the opening would not prevent the safe shutdown of the plant and would not result in an offsite release exceeding the limits defined in 10 CFR 100 (Reference 3.5-2)."

- Change the first sentence in the second paragraph of Subsection 3.5.2 to:

"Openings through exterior walls of the seismic Category I structures are evaluated as described in Subsection 3.5.1.4 to provide confidence that a missile passing through the opening would not prevent safe shutdown and would not result in an offsite release exceeding the limits defined in 10 CFR 100 (Reference 3.5-2)."

Impact on COLA

There is no impact on COLA.

Impact on PRA

There is no impact on PRA.

This completes MHI's response to the NRC's question.

outlined in the geometry Section 3.5.1.3, the product of P_2 and P_3 is conservatively estimated as 10^{-3} per year. The determination of P_1 (probability of turbine failure resulting in the ejection of turbine rotor (or internal structure) fragments through the turbine casing) is strongly influenced by the program for periodic inservice testing and inspection. Criteria as described in NUREG-0800 Standard Review Plan 3.5.1.3, Table 3.5.1.3-1 (Reference 3.5-7) correlates P_1 to operating cases necessary to obtain P_4 in an acceptable risk rate of 10^{-7} per year, where P_1 is less than $P_4 / (P_2 \times P_3)$ or 10^{-4}. The P_1 applicable to the US-APWR is described in Subsection 10.2.2. The COL Applicant is to commit to actions to maintain P_1 within this acceptable limit as provided by turbine and rotor design features, material specifications and recommended inspections during preservice and inservice periods based on Technical Report, MUAP-070028-NP, Probability of Missile Generation From Low Pressure Turbines (Reference 3.5-17). Inservice inspection programs are to be maintained as outlined in SRP 3.5.1.3, Section II, Acceptance Criteria, Section 5 (Reference 3.5-7) for turbine installations without NRC-approved reports describing methods and procedures for calculating turbine missile generation probabilities.

3.5.1.4 Missiles Generated by Tornadoes and Extreme Winds

The US-APWR design basis spectrum of tornado missiles conforms to the spectrum of missiles defined in Table 2 of "Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants", RG 1.76, Rev.1 (Reference 3.5-8) for a region I tornado, the most severe. The spectrum of missiles is chosen to represent: (1) a massive high-kinetic-energy missile that deforms on impact, (2) a rigid missile that tests penetration resistance, and (3) a small rigid missile of a size sufficient to pass through any opening in protective barriers.

Therefore, the spectrum of tornado missiles is as follows:

- A 4,000 pound automobile, 16.4 ft by 6.6 ft by 4.3 ft, impacting the structure at normal incidence with a horizontal velocity of 135 ft/s or a vertical velocity of 90.5 ft/s. This missile is considered to potentially impact at all plant elevations up to 30 ft above grade for all grades within 0.5 mile of the plant structures.
- A 6.625 inch diameter by 15 ft long schedule 40 pipe, weighing 287 pounds, impacting the structure end-on at normal incidence with a horizontal velocity of 135 ft/s or a vertical velocity of 90.5 ft/s.
- A 1 inch diameter solid steel sphere assumed to impinge upon barrier openings in the most damaging direction with a velocity of 26 ft/s in any direction.

Because of the higher wind speed and the resulting higher kinetic energy, the design for wind-generated missiles is governed by tornado missiles and not hurricane missiles. Therefore, US-APWR seismic category I and II structures are not designed for hurricane missiles, because the design for tornado missiles envelopes the design for hurricane missiles.

Openings through the exterior walls of the seismic ~~e~~Category I structures, and the location of equipment in the vicinity of such openings, are arranged so that a missile passing through the opening would not prevent the safe shutdown of the plant and would not result in an offsite release exceeding the limits defined in 10 CFR 100 (Reference 3.5-2). Otherwise, structural barriers are designed to resist tornado missiles in

accordance with the design procedures discussed in Subsection 3.5.3. Tornado missiles are not postulated to ricochet or strike more than once at a target location. Tornado missile protection is provided to resist the normal component of force delivered by the missile striking in any direction. Due to the robustness of design, all seismic Category I structures are capable of withstanding the impact of each identified tornado missile at any elevation, including the potential of a 4,000 pound automobile in excess of 30 feet above grade.

3.5.1.5 Site Proximity Missiles (Except Aircraft)

Externally initiated missiles considered for the US-APWR standard design are based on tornado missiles as described in Subsection 3.5.1.4. As described in DCD, Section 2.2, the COL Applicant is to establish the presence of potential hazards, except aircraft, which is reviewed in Subsection 3.5.1.6, and the effects of potential accidents in the vicinity of the site. The RG followed is identified, and any deviations from this guidance or any alternative methods that are used are explained or justified. The information also describes the data collected, analyses performed, results obtained, and any previous analyses and results cited to justify any of the conclusions. Additional analyses may be required to evaluate other potential site-specific missiles.

3.5.1.6 Aircraft Hazards

The US-APWR standard plant design basis is that the plant is located such that an aircraft crash and air transportation accidents are not required to be considered as part of the design basis. It is the responsibility of the COL Applicant to verify the site interface parameters with respect to aircraft crashes and air transportation accidents as described in Section 2.2. Additional analyses may be required to evaluate potential aircraft missiles.

3.5.2 Structures, Systems, and Components to be Protected from Externally Generated Missiles

Safety-related SSCs are identified in Section 3.2 and Section 3.11. Protection of these systems from external missiles is provided by the external walls and roof of the safety-related R/B and PS/B. The external walls and roofs are reinforced concrete. The structural design requirements for the R/B and PS/B are outlined in Subsection 3.8.4.

Openings through exterior walls of the seismic Category I structures are evaluated ~~on a case-by-case basis~~ as described in Subsection 3.5.1.4 to provide confidence that a missile passing through the opening would not prevent safe shutdown and would not result in an offsite release exceeding the limits defined in 10 CFR 100 (Reference 3.5-2). The COL Applicant is responsible to evaluate site-specific hazards for external events that may produce missiles more energetic than tornado missiles, and assure that the design of seismic category I and II structures meet these loads.

3.5.3 Barrier Design Procedures

If required, components, protective shields, and missile barriers are designed to prevent damage to safety-related components by absorbing and withstanding missile impact loads. The target SSCs, shields, and barriers are evaluated for both local effects and overall structural effects due to missile impacts. The local effects in the impacted area

Docket No. 52-021
MHI Ref: UAP-HF-09038

Enclosure 3

UAP-HF-09038
Docket No. 52-021

Response to Request for Additional Information No. 154-1643,
Revision 0

February, 2009

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

2/04/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 154-1643 REVISION 0**
SRP SECTION:	**03.05.01.04 – Missiles Generated by Tornadoes and Extreme Winds**
APPLICATION SECTION:	**03.05.01.04**
DATE OF RAI ISSUE:	**01/12/09**

QUESTION NO. : RAI 3.5.1.4-01

In DCD Tier 2, Revision 1, Section 3.3.2.1 Mitsubishi provided the following parameters as design basis tornado parameters for the US-APWR design:

- Maximum wind speed of 370 km/h (230 mph)
- Maximum rotational speed of 296 km/h (184 mph)
- Maximum translational speed of 74 km/h (46 mph)
- Radius of maximum rotational speed of 45.7m (150 ft)
- Atmospheric pressure drop of 8.3 kPa (1.2 psi)
- Rate of pressure drop of 3.4 kPa/s (0.5 psi/s)
- Exceedance frequency of 1×10^{-7} per year

However, the staff finds that not all the above design basis tornado parameters are included in DCD Tier 1, Revision 1, Table 2.1-1, "Key Site Parameters." Therefore, revise DCD Tier 1, Revision 1, Table 2.1-1 to include maximum rotational speed of 296 km/h (184 mph), maximum translational speed of 74 km/h (46 mph), radius of maximum rotational speed of 45.7m (150 ft), rate of pressure drop of 3.4 kPa/s (0.5 psi/s), and exceedance frequency of 1×10^{-7} per year. Include this information in the DCD and provide a markup in your response.

ANSWER:

Both Tier 1 Table 2.1-1 and Tier 2 Table 2.0-1 will be revised to include maximum rotational speed of 184 mph, maximum translational speed of 46 mph, radius of maximum rotational speed of 150 ft, and rate of pressure drop of 0.5 psi/s. However, the exceedance frequency is an acceptance value for frequency of occurrence, which is not a key site parameter. Therefore, the exceedance frequency is not applicable for inclusion in these tables.

Impact on DCD

See Attachment 1 for a mark-up of DCD Tier 1, Chapter 2, Revision 2, changes to be incorporated:

- Include the following parameter values of tornado maximum rotational wind speed, translational wind speed, radius of maximum rotational speed, and rate of pressure drop on sheet 1 of Tier 1, Table 2.1-1:

Tornado maximum wind speed	230 mph
	184 mph maximum rotational
	46 mph maximum translational
Radius of maximum rotational speed	150 ft
Tornado maximum pressure drop	1.2 psi
Rate of pressure drop	0.5 psi/s

See Attachment 2 for a mark-up of DCD Tier 2, Chapter 2, Revision 2, changes to be incorporated:

- Include the following parameter values of tornado maximum rotational wind speed, translational wind speed, radius of maximum rotational speed, and rate of pressure drop on sheet 1 of Tier 2, Table 2.0-1:

Tornado maximum wind speed	230 mph
	184 mph maximum rotational
	46 mph maximum translational
Radius of maximum rotational speed	150 ft
Tornado maximum pressure drop	1.2 psi
Rate of pressure drop	0.5 psi/s

Impact on COLA

There is no impact on COLA.

Impact on PRA

There is no impact on PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

2/04/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 154-1643 REVISION 0**
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APPLICATION SECTION:	**03.05.01.04**
DATE OF RAI ISSUE:	**01/12/09**

QUESTION NO. : RAI 3.5.1.4-02

The design basis tornado parameters and tornado-generated missile spectra provided In DCD Tier 2, Revision 1, Section 3.3.2.1 and Table 2.0-1, respectively are consistent with the guidance as described in RG 1.76 for Region 1.

RG 1.76 only applies to the continental United States, which is divided into three regions (the central portion of the United States; a large region of the United States along the east coast, the northern border, and western Great Plains; and the western United States). Revise DCD Tier 2, Revision 1, Table 1.8.2, "Compilation of All Combined License Applicant Items for Chapters 1-19," and Section 3.5.4 to include a COL information item that requires a COL applicant that references the US-APWR design certification for a site located outside the continental United States to confirm that the design basis tornado parameters are within those specified for the US-APWR design. Include this information in the DCD and provide a markup in your response.

ANSWER:

Current COL information item *COL 2.3(1)* in DCD Tier 2 Table 1.8.2 and Subsection 2.3.1 require the COL Applicant to verify the site-specific regional climatology and local meteorology are bounded by the site parameters of the standard plant design, which include the design basis tornado parameters and tornado-generated missile spectra stated in the DCD. Any COL application for a site located outside as well as inside the continental United States is required to compare the design basis tornado parameters and tornado-generated missile spectra with those specified for the US-APWR design. No additional COL information item is therefore necessary to address COL applications for a site uniquely located outside the continental United States.

Impact on DCD

There is no impact on DCD.

Impact on COLA

There is no impact on COLA.

Impact on PRA

There is no impact on PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

2/04/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

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DATE OF RAI ISSUE:	**01/12/09**

QUESTION NO. : RAI 3.5.1.4-03

In DCD Tier 2, Revision 1, Section 3.5.1.4 Mitsubishi states that because of the higher wind speed and the resulting higher kinetic energy, the design for wind-generated missiles is governed by tornado missiles and not hurricane missiles. Therefore, US-APWR seismic category I and II structures are not designed for hurricane missiles, because the design for tornado missiles envelopes the design for hurricane missiles. The staff does not concur with Mitsubishi that the design for tornado missiles will envelope the design for hurricane missiles.

RG 1.76 does not address extreme winds such as hurricanes, or the missiles attributed to such winds. RG 1.76 states that tornado wind speeds may not bound hurricane wind speeds for certain portions of the Atlantic and Gulf coasts, at the wind speed frequencies of occurrence considered in this guide. Therefore, revise DCD Tier 2, Revision 1, Table 1.8.2 and Section 3.5.4 to include a COL information item that requires a COL applicant that references the US-APWR design certification for a site located in certain portions of the Atlantic and Gulf coasts to confirm that tornado wind speeds bound hurricane wind speeds for that portions of the Atlantic and Gulf coasts, at the wind speed frequencies of occurrence considered in RG 1.76. Include this information in the DCD and provide a markup in your response.

ANSWER:

As stated in response to RAI 3.5.1.4-02 above, current COL information item *COL 2.3(1)* in DCD Tier 2 Table 1.8.2 and Subsection 2.3.1 requires the COL Applicant to verify the site-specific regional climatology and local meteorology are bounded by the site parameters. In addition, COL Item 3.5(5) in Subsections 3.5.2 and 3.5.4 states the COL Applicant is responsible to evaluate site-specific hazards for external events that may produce missiles more energetic than tornado missiles, and assure that the design of seismic Category I and II structures meet these loads. No additional COL information item is therefore necessary to evaluate a site uniquely located in certain portions of the Atlantic and Gulf coasts.

To allow for the potential for hurricane missiles in excess of standard plant design criteria, the third paragraph in DCD Subsection 3.5.1.4, beginning "Because of the higher wind speed ...", will be deleted in its entirety.

Impact on DCD

See Attachment 3 for a mark-up of DCD Tier 2, Section 3.5, Revision 2, changes to be incorporated:

- Delete the third paragraph in Subsection 3.5.1.4 in its entirety.

Impact on COLA

There is no impact on COLA.

Impact on PRA

There is no impact on PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

2/04/2009

US-APWR Design Certification

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Docket No. 52-021

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QUESTION NO. : RAI 3.5.1.4-04

In DCD Tier 2 Section 3.3.2.1 Revision 1, Mitsubishi states that for the design basis tornado the annual exceedance probability tornado is above 10^{7} while SRP Section 3.5.1.4, Revision 3 states that evolutionary reactors should be designed based on a design basis tornado strike probability of 10^{-7} per year as defined in RG 1.76.

The staff believes that the above cited discrepancy between DCD Tier 2 Section 3.3.2.1 Revision 1 and SRP Section 3.5.1.4, Revision 3 is due to typo error. Therefore, revise the DCD to clarify this typo error.

Also, revise DCD Tier 2, Revision 1, Table 1.8.2, "Compilation of All Combined License Applicant Items for Chapters 1-19," to include a COL information item to require the COL applicant that references the US-APWR design certification to confirm that the probable occurrence of the site proximity missile (except aircraft) is less than $1x10^{-7}$ per year based on the site-specific information in accordance with SRP Section 3.5.1.5. Include this information in the DCD and provide a markup in your response.

ANSWER:

As noted by the NRC regarding Subsection 3.3.2.1, typographical error "10^{7}" will be corrected to "10^{-7}".

Current COL information item *COL 2.2(1)* in DCD Tier 2 Table 1.8.2 and Section 2.2 requires the COL Applicant to describe nearby industrial, transportation, and military facilities within 5 miles of the site, or at greater distances as appropriate based on their significance. The COL Applicant is also to establish the presence of potential hazards, and to determine whether these accidents are to be considered as design basis events (DBEs). Subsection 2.2.3 identifies the determination of DBEs as a 10^{-7} per year or greater occurrence rate with potential consequences serious enough to affect the safety of the plant.

By reference to DCD Tier 2, Section 2.2 from Subsection 3.5.1.5, a COL information item already exists to require the COL Applicant that references the US-APWR design certification to confirm that the probable occurrence of the site proximity missile (except aircraft) is less than $1x10^{-7}$ per year based on the site-specific information in accordance with SRP Section 3.5.1.5.

Impact on DCD

See Attachment 4 for a mark-up of DCD Tier 2, Section 3.3, Revision 2, change to be incorporated:

- Change the third sentence in second paragraph of Subsection 3.3.2.1 from "... described above is 10^{7} as discussed ..." to "... described above is 10^{-7} as discussed ..."

Impact on COLA

There is no impact on COLA.

Impact on PRA

There is no impact on PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

2/04/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 154-1643 REVISION 0**
SRP SECTION:	**03.05.01.04 – Missiles Generated by Tornadoes and Extreme Winds**
APPLICATION SECTION:	**03.05.01.04**
DATE OF RAI ISSUE:	**01/12/09**

QUESTION NO. : RAI 3.5.1.4-05

In the US-APWR design basis tornado parameters, automobile missiles are considered to impact at an altitude of less than 9.1 m (30 ft) above plant grade. Therefore, for sites with surrounding ground elevations higher than plant grade, a COL applicant that references the US-APWR design certification should confirm that automobile missiles cannot be generated within a 0.5 mile radius of safety related SSCs that would lead to impact higher than 30 ft above plant grade.

Revise DCD Tier 2, Revision 1, Table 1.8.2, to include a COL information item to require the COL applicant that references the US-APWR design certification to confirm that automobile missiles cannot be generated within a 0.5 mile radius of safety-related SSCs that would lead to impact higher than 30 ft above plant grade. Include this information in the DCD and provide a markup in your response.

ANSWER:

Subsection 3.5.1.4 will be revised to reflect that the entire height of exterior walls of seismic Category I buildings have thicknesses sufficient to withstand the impact of each identified tornado missile at any elevation, including the potential of a 4,000 pound automobile. Therefore, an additional COL item is not necessary to evaluate plant elevation in excess of building grade level. A statement is to be added to DCD Tier 2, Subsection 3.5.1.4 that indicates the entire height of exterior walls of seismic Category I buildings have thicknesses sufficient to withstand the impact of each identified tornado missile at any elevation, including the potential of a 4,000 pound automobile.

Impact on DCD

See Attachment 3 for a mark-up of DCD Tier 2, Section 3.5, Revision 2, changes to be incorporated:

- Add the following as the last sentence of the last paragraph in Subsection 3.5.1.4:

"Due to the robustness of the exterior wall design, all seismic Category I structures are capable of withstanding the impact of each identified tornado missile at any elevation, including the potential impact of a 4,000 pound automobile greater than 30 feet above grade."

Impact on COLA

There is no impact on COLA.

Impact on PRA

There is no impact on PRA.

This completes MHI's responses to the NRC's questions.

ATTACHMENT 1
to RAI 154-1643

Table 2.1-1 Key Site Parameters
(Sheet 1 of 5)

Meteorology	
Parameter Description	**Parameter Value**
Roof Snow Load (100-year snowpack maximum snow weight including contributing portion of 48-hour probable maximum winter precipitation [PMWP])	75 lb/ft^2
Weight of 48-hr PMWP	50 lb/ft^2
Tornado maximum wind speed	230 mph
	184 mph maximum rotational
	46 mph maximum translational
Radius of maximum rotational speed	150 ft
Tornado maximum pressure drop	1.2 psi
Rate of pressure drop	0.5 psi/s
Tornado-generated missile spectrum and associated velocities	15 ft long schedule 40 steel pipe moving horizontally at 135 ft/s(1)
	4,000 lb automobile moving horizontally at 135 ft/s(1)
	1 in diameter steel sphere moving horizontally at 26 ft/s(1)
Extreme wind speed (other than in tornado)	155 mph for 3-second gusts at 33 ft above ground level based on 100-year return period, with importance factor of 1.15 for seismic category I/II structures
Ambient design air temperature (1% annual exceedance maximum)	100°F dry bulb, 77°F coincident wet bulb, 81°F non-coincident wet bulb
Ambient design air temperature (0% annual exceedance maximum)	115°F dry bulb, 80°F coincident wet bulb, 86°F non-coincident wet bulb, historical limit excluding peaks <2 hr
Ambient design air temperature (1% annual exceedance minimum)	-10°F dry bulb
Ambient design air temperature (0% annual exceedance minimum)	-40°F dry bulb, historical limit excluding peaks <2 hr
Atmospheric dispersion factors (χ/Q values) for onsite locations:	
Exclusion area boundary (EAB) 0-2 hrs	5.0×10^{-4} s/m^3
EAB annual average	1.6×10^{-5} s/m^3

Table 2.0-1 Key Site Parameters
(Sheet 1 of 5)

Meteorology	
Parameter Description	**Parameter Value**
Roof Snow Load (100-year snowpack maximum snow weight including contributing portion of 48-hour probable maximum winter precipitation [PMWP])	75 lb/ft^2
Weight of 48-hr PMWP	50 lb/ft^2
Tornado maximum wind speed	230 mph
	184 mph maximum rotational
	46 mph maximum translational
Radius of maximum rotational speed	150 ft
Tornado maximum pressure drop	1.2 psi
Rate of pressure drop	0.5 psi/s
Tornado-generated missile spectrum and associated velocities	15 ft long schedule 40 steel pipe moving horizontally at 135 ft/s[(1)]
	4,000 lb automobile moving horizontally at 135 ft/s[(1)]
	1 in diameter steel sphere moving horizontally at 26 ft/s[(1)]
Extreme wind speed (other than in tornado)	155 mph for 3-second gusts at 33 ft above ground level based on 100-year return period, with importance factor of 1.15 for seismic category I/II structures
Ambient design air temperature (1% annual exceedance maximum)	100°F dry bulb, 77°F coincident wet bulb, 81°F non-coincident wet bulb
Ambient design air temperature (0% annual exceedance maximum)	115°F dry bulb, 80°F coincident wet bulb, 86°F non-coincident wet bulb, historical limit excluding peaks <2 hr
Ambient design air temperature (1% annual exceedance minimum)	-10°F dry bulb
Ambient design air temperature (0% annual exceedance minimum)	-40°F dry bulb, historical limit excluding peaks <2 hr
Atmospheric dispersion factors (χ/Q values) for onsite locations:	
Exclusion area boundary (EAB) 0-2 hrs	5.0×10^{-4} s/m^3
EAB annual average	1.6×10^{-5} s/m^3

outlined in the geometry Section 3.5.1.3, the product of P_2 and P_3 is conservatively estimated as 10^{-3} per year. The determination of P_1 (probability of turbine failure resulting in the ejection of turbine rotor (or internal structure) fragments through the turbine casing) is strongly influenced by the program for periodic inservice testing and inspection. Criteria as described in NUREG-0800 Standard Review Plan 3.5.1.3, Table 3.5.1.3-1 (Reference 3.5-7) correlates P_1 to operating cases necessary to obtain P_4 in an acceptable risk rate of 10^{-7} per year, where P_1 is less than $P_4 / (P_2 \times P_3)$ or 10^{-4}. The P_1 applicable to the US-APWR is described in Subsection 10.2.2. The COL Applicant is to commit to actions to maintain P_1 within this acceptable limit as provided by turbine and rotor design features, material specifications and recommended inspections during preservice and inservice periods based on Technical Report, MUAP-070028-NP, Probability of Missile Generation From Low Pressure Turbines (Reference 3.5-17). Inservice inspection programs are to be maintained as outlined in SRP 3.5.1.3, Section II, Acceptance Criteria, Section 5 (Reference 3.5-7) for turbine installations without NRC-approved reports describing methods and procedures for calculating turbine missile generation probabilities.

3.5.1.4 Missiles Generated by Tornadoes and Extreme Winds

The US-APWR design basis spectrum of tornado missiles conforms to the spectrum of missiles defined in Table 2 of "Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants", RG 1.76, Rev.1 (Reference 3.5-8) for a region I tornado, the most severe. The spectrum of missiles is chosen to represent: (1) a massive high-kinetic-energy missile that deforms on impact, (2) a rigid missile that tests penetration resistance, and (3) a small rigid missile of a size sufficient to pass through any opening in protective barriers.

Therefore, the spectrum of tornado missiles is as follows:

- A 4,000 pound automobile, 16.4 ft by 6.6 ft by 4.3 ft, impacting the structure at normal incidence with a horizontal velocity of 135 ft/s or a vertical velocity of 90.5 ft/s. This missile is considered to potentially impact at all plant elevations up to 30 ft above grade for all grades within 0.5 mile of the plant structures.
- A 6.625 inch diameter by 15 ft long schedule 40 pipe, weighing 287 pounds, impacting the structure end-on at normal incidence with a horizontal velocity of 135 ft/s or a vertical velocity of 90.5 ft/s.
- A 1 inch diameter solid steel sphere assumed to impinge upon barrier openings in the most damaging direction with a velocity of 26 ft/s in any direction.

~~Because of the higher wind speed and the resulting higher kinetic energy, the design for wind-generated missiles is governed by tornado missiles and not hurricane missiles. Therefore, US-APWR seismic category I and II structures are not designed for hurricane missiles, because the design for tornado missiles envelopes the design for hurricane missiles.~~

Openings through the exterior walls of the seismic category I structures, and the location of equipment in the vicinity of such openings, are arranged so that a missile passing through the opening would not prevent the safe shutdown of the plant. Otherwise, structural barriers are designed to resist tornado missiles in accordance with the design procedures discussed in Subsection 3.5.3. Tornado missiles are not postulated to

ricochet or strike more than once at a target location. Tornado missile protection is provided to resist the normal component of force delivered by the missile striking in any direction. Due to the robustness of the exterior wall design, all seismic Category I structures are capable of withstanding the impact of each identified tornado missile at any elevation, including the potential of a 4,000 pound automobile greater than 30 feet above grade.

3.5.1.5 Site Proximity Missiles (Except Aircraft)

Externally initiated missiles considered for the US-APWR standard design are based on tornado missiles as described in Subsection 3.5.1.4. As described in DCD, Section 2.2, the COL Applicant is to establish the presence of potential hazards, except aircraft, which is reviewed in Subsection 3.5.1.6, and the effects of potential accidents in the vicinity of the site. The RG followed is identified, and any deviations from this guidance or any alternative methods that are used are explained or justified. The information also describes the data collected, analyses performed, results obtained, and any previous analyses and results cited to justify any of the conclusions. Additional analyses may be required to evaluate other potential site-specific missiles.

3.5.1.6 Aircraft Hazards

The US-APWR standard plant design basis is that the plant is located such that an aircraft crash and air transportation accidents are not required to be considered as part of the design basis. It is the responsibility of the COL Applicant to verify the site interface parameters with respect to aircraft crashes and air transportation accidents as described in Section 2.2. Additional analyses may be required to evaluate potential aircraft missiles.

3.5.2 Structures, Systems, and Components to be Protected from Externally Generated Missiles

Safety-related SSCs are identified in Section 3.2 and Section 3.11. Protection of these systems from external missiles is provided by the external walls and roof of the safety-related R/B and PS/B. The external walls and roofs are reinforced concrete. The structural design requirements for the R/B and PS/B are outlined in Subsection 3.8.4.

Openings through exterior walls are evaluated on a case-by-case basis to provide confidence that a missile passing through the opening would not prevent safe shutdown and would not result in an offsite release exceeding the limits defined in 10 CFR 100 (Reference 3.5-2). The COL Applicant is responsible to evaluate site-specific hazards for external events that may produce missiles more energetic than tornado missiles, and assure that the design of seismic category I and II structures meet these loads.

3.5.3 Barrier Design Procedures

If required, components, protective shields, and missile barriers are designed to prevent damage to safety-related components by absorbing and withstanding missile impact loads. The target SSCs, shields, and barriers are evaluated for both local effects and overall structural effects due to missile impacts. The local effects in the impacted area are evaluated to predict the minimum thickness required for steel structures and for concrete structures to prevent perforation and the potential generation of secondary

3.3.2.1 Applicable Design Parameters

The design basis tornado parameters are for a single Rankine combined vortex tornado and are as follows.

- Maximum wind speed = 230 mph (maximum rotational + maximum translational)
- Maximum rotational speed = 184 mph
- Maximum translational speed = 46 mph
- Radius of maximum rotational wind from center of tornado, R_m = 150 ft
- Atmospheric pressure drop = 1.2 psi
- Rate of pressure change = 0.5 psi/second

The parameters listed above are based on US NRC RG 1.76, Revision 1, dated March 2007 (Reference 3.3-4). The parameters are those of a region 1 tornado as defined therein, and envelope the tornadoes of all other regions in the contiguous US. The annual probability of exceedance of the design basis tornado described above is 10^{-7} as discussed in RG 1.76 and the corresponding recurrence interval is approximately one million years.

3.3.2.2 Determination of Forces on Structures

3.3.2.2.1 Tornado Velocity Forces

Velocity pressures are determined by converting tornado wind speeds into effective velocity pressures in accordance with procedures accepted by SRP 3.3.1 (Reference 3.3-5). Design tornado loads are determined for enclosed and partially enclosed buildings using the analytical procedure method 2 provided in Subsection 3.3.1.2, where:

K_z is the velocity pressure exposure coefficient = 0.87

V is the maximum tornado wind speed = 230 mph

For the design basis tornado, wind speed remains constant with respect to height; therefore, no adjustment for wind speed variation with respect to height applies.

The design load equation in Subsection 3.3.1.2 above is for enclosed and partially enclosed buildings per ASCE/SEI 7-05, Subsection 6.5.12. ASCE/SEI 7-05 (Reference 3.3-1) Subsections 6.5.13 to 6.5.15 are used for the determination of design loads for different structure types as applicable.

3.3.2.2.2 Tornado Atmospheric Forces

The tornado atmospheric pressure loading is computed using the maximum atmospheric pressure drop defined in Subsection 3.3.2.1, and the ability of the structure to reduce atmospheric pressure change by venting.

For a structure that is enclosed (unvented structure), the atmospheric pressure outside the structure changes during the passage of a tornado, while the internal pressure