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April 9, 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-09150

Subject: MHI's Response to US-APWR DCD RAI No. 218-1907

Reference: 1) "Request for Additional Information No. 218-1907 Revision 0, SRP Section: 03.03.02 – Tornado Loads, Application Section: 03.03.02," dated 2/26/2009.

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. 218-1907, Revision 0."

Enclosed are the responses to 4 RAIs contained within Reference 1, including RAI 3.3.2-02 which has a 60-day response time.

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.

Enclosure:

1. Responses to Request for Additional Information No. 218-1907, Revision 0

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

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NRO

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Docket No. 52-021
MHI Ref: UAP-HF-09150

Enclosure 1

UAP-HF-09150
Docket No. 52-021

Responses to Request for Additional Information No. 218-1907, Revision 0

April, 2009

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

4/9/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 218-1907 REVISION 0**
SRP SECTION:	**03.03.02 – Tornado Loadings**
APPLICATION SECTION:	**03.03.02**
DATE OF RAI ISSUE:	**02/26/09**

QUESTION NO. RAI 3.3.2-01:

1. RAI Text

Meteorological and topographic conditions, which vary significantly within the continental United States, influence the frequency of occurrence and intensity of tornadoes. The NRC staff has determined that the design-basis tornado wind speeds for new reactors correspond to the exceedance frequency of 10^{-7} per year as stated in Regulatory Guide 1.76, Rev. 1. However, the applicant used a different exceedance frequency in the DCD. Because these exceedance frequency values are not the same, the applicant is requested to provide the technical basis for using a different exceedance frequency.

2. Concern

The US-APWR applicant states that:

> "The parameters listed above are based on US NRC RG 1.76, Rev. 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."

Comparison of the text in Regulatory Guide 1.76, Rev. 1 and the text presented by the US-APWR applicant on the subject of tornado exceedance frequency indicates inconsistencies.

In order for the NRC staff to verify that the US-APWR applicant has a complete and thorough understanding of the design basis for tornado characteristics and tornado missiles for nuclear power plants, the applicant is requested to provide an explanation for the differences in exceedance frequency values.

3. Applicant References

DCD Tier 2, Revision 1, Section 3.3.2.1

4. Context

Structural integrity of Seismic Category I structures, which assures that SSCs important to safety are protected, and not compromised according to GDC-2 in the Appendix A to Part 50 of 10 CFR.

5. Priority/Impact

Medium – information is essential to completing a technical review and resolving a safety issue. The review can continue, but cannot be completed without the requested additional information.

6. Dependencies

Internal – There are interfaces with SRP Chapter 3.0, Section 3.5.1.4.

External – There are no external dependencies.

ANSWER:

The typographical error "10^{7}" was previously identified for correction to "10^{-7}" by RAI No. 154-1643, Question RAI 3.5.1.4-04.

Impact on DCD

DCD Revision 2 will incorporate the following changes:

- Refer to Impact on DCD for RAI 154-1643, Question 3.5.1.4-04, for changes to Subsection 3.3.2.1 that are applicable to this response for RAI 218-1907, Question RAI 3.3.2-01.

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

4/9/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 218-1907 REVISION 0**
SRP SECTION:	**03.03.02 – Tornado Loadings**
APPLICATION SECTION:	**03.03.02**
DATE OF RAI ISSUE:	**02/26/09**

QUESTION NO. RAI 3.3.2-02:

1. RAI Text

The design-basis tornado missile spectrum and maximum horizontal speeds that are acceptable to the NRC staff are defined in Table 2 of Regulatory Guide 1.76, Rev. 1. The three types of missiles included in the spectrum are (1) a schedule 40 pipe, (2) an automobile, and (3) a solid steel sphere. According to the US-APWR applicant:

"Overall effects of missile impact are designed for flexural, shear, and buckling effects on structural members using the equivalent static load obtained from the evaluation of structural response. The impact is assumed to be plastic, and is determined as outlined in "Impact Effect of Fragments Striking Structural Elements" (Reference 3.3-6)."

Provide a description of the fragment spectrum considered in Reference 3.3-6 and identify the missiles included in the fragment spectrum, if any, which are capable of producing tornado missile impact effects that are more severe than those produced by the missiles listed in the missile spectrum defined in Regulatory Guide 1.76, Rev. 1.

2. Concern

Compliance with GDC 2 requires that nuclear power plant SSCs are designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform their intended safety functions. The design-basis tornado-generated missile spectrum in Table 2 of Regulatory Guide 1.76, Rev. 1 is generally acceptable to the NRC staff for the design of nuclear power plants. However, other possible types of missiles that could adversely affect SSCs by reducing their capability to perform their intended safety functions should be analyzed by the applicant to ensure compliance with GDC 2 requirements.

In order for the NRC staff to verify compliance with requirements in GDC-2 in 10 CFR 50, Appendix A, the applicant is requested to provide information about all potential tornado-generated missiles and fragments identified by the applicant that could produce tornado-generated missile impact effects more severe than those produced by the missiles included in the missile spectrum defined in Regulatory Guide 1.76, Rev. 1.

3. Applicant References

DCD Tier 2, Revision 1, Section 3.3.2.2.3.

4. Context

Structural integrity of Seismic Category I structures, which assures that SSCs important to safety are protected, and not compromised according to GDC-2 in the Appendix A to Part 50 of 10 CFR.

5. Priority/Impact

Medium – information is essential to completing a technical review and resolving a safety issue. The review can continue, but cannot be completed without the requested additional information.

6. Dependencies

Internal – There are interfaces with SRP Chapter 3.0, Sections 3.5.1.4 and 3.5.3.

External – There are no external dependencies.

ANSWER:

DCD Section 3.5.1.4 outlines the tornado missile spectrum for the standard plant design. This spectrum is consistent with the missile spectrum defined in Table 2 of Regulatory Guide 1.76, Rev. 1 and is listed among the key site parameters of the US-APWR in Table 2.0-1 of Tier 2 Chapter 2 of the DCD. As stated in DCD Section 2.3, the COL Applicant Item COL 2.3(1) is to verify the site-specific regional climatology and local meteorology are bounded by the site parameters for the standard US-APWR design, or to demonstrate by some other means that the proposed facility and associated site-specific characteristics are acceptable at the proposed site. In addition, any tornado-generated missile fragments that could produce tornado-generated missile impact effects more severe than those defined in Regulatory Guide 1.76, Rev. 1 must be considered by COL applicants as required by COL Item 3.3(3) on a project-specific basis.

"Impact Effect of Fragments Striking Structural Elements" (DCD Reference 3.3-6) does not provide a tornado-generated missile spectrum. It outlines a method used to obtain an equivalent static load for use in a structural analysis. The missile spectrum in Regulatory Guide 1.76, Rev. 1 as well as any other tornado-generated missile spectrum can be analyzed using the method given in Reference 3.3-6. DCD Subsection 3.3.2.2.3 will be revise to clarify the reference document provides the methodology for determining impact forces.

Impact on DCD

See Attachment 1 for a mark-up of DCD Tier 2, Section 3.3, Revision 2, changes to be incorporated.

- Change the last sentence in the last paragraph of Subsection 3.3.2.2.3 to: "The impact is assumed to be plastic, and impact forces are determined as outlined in "Impact Effect of Fragments Striking Structural Elements" (Reference 3.3-6)."

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

4/9/2009

US-APWR Design Certification
Mitsubishi Heavy Industries
Docket No. 52-021

RAI NO.:	**NO. 218-1907 REVISION 0**
SRP SECTION:	**03.03.02 – Tornado Loadings**
APPLICATION SECTION:	**03.03.02**
DATE OF RAI ISSUE:	**02/26/09**

QUESTION NO. RAI 3.3.2-03:

1. RAI Text

The two equations used by the applicant to determine the combined tornado effects are consistent with the two equations for combined tornado effects in SRP Section 3.3.2. However, the applicant is requested to provide additional information about the technical approach being used to ensure that the combination of tornado effects for a structure is established in a conservative manner.

2. Concern

Wind speed variation and atmospheric pressure change associated with the passage of a tornado are modeled as a single Rankine combined vortex as described in Regulatory Guide 1.76, Rev 1. These two phenomena produce tornado wind effects and atmospheric pressure change effects that can adversely affect the ability of SSCs to perform their intended safety functions. In addition, tornado-generated missiles can produce tornado missile impact effects that can affect SSCs. Determining the combination of these effects that controls the design of the SSCs in a conservative manner requires an analysis that takes many different tornado-related variables and structural parameters into consideration.

In order for the NRC staff to verify compliance with requirements in GDC-2 in 10 CFR 50, Appendix A, the applicant is requested to provide a complete description of the approach taken by the applicant to ensure that the combination of tornado effects for each Seismic Category I structure is established in a conservative manner.

3. Applicant References

DCD Tier 2, Revision 1, Section 3.3.1.2.

4. Context

Structural integrity of Seismic Category I structures, which assures that SSCs important to safety are protected, and not compromised according to GDC-2 in the Appendix A to Part 50 of 10 CFR.

5. Priority/Impact

Medium – information is essential to completing a technical review and resolving a safety issue. The review can continue, but cannot be completed without the requested additional information.

6. Dependencies

Internal – There are interfaces with SRP Chapter 3.0, Sections 3.5.1.4 and 3.5.3.

External – There are no external dependencies.

ANSWER:

Combinations of the three individual tornado effects (direct wind pressure, atmospheric pressure change, and tornado missiles) are in accordance with SRP 3.3.2 and will be supplemented with the design criteria and procedures provided in the Bechtel Topical Report BC-TOP-3-A, Revision 3, "Tornado and Extreme Wind Design Criteria for Nuclear Power Plants".

DCD Subsection 3.3.2.2.4 will be clarified by expanding the existing two combination equations to the six combination equations in Section 3.4 of the Bechtel Topical Report BC-TOP-3-A as listed below.

$W_t = W_w$

$W_t = W_p$

$W_t = W_m$

$W_t = W_w + 0.5\ W_p$

$W_t = W_w + W_m$

$W_t = W_w + 0.5\ W_p + W_m$

where

W_t = total tornado load

W_w = load from tornado wind effect

W_p = load from tornado atmospheric pressure change effect

W_m = load from tornado missile impact effect

Impact on DCD

See Attachment 1 for a mark-up of DCD Tier 2, Section 3.3, Revision 2, changes to be incorporated.

- Add the following as the first sentence in the first paragraph of Subsection 3.3.2.2.4: "The loading combinations of the individual tornado loading components are in accordance with SRP 3.3.2 (Reference 3.3-5) and are supplemented with the design criteria and procedures provided in BC-TOP-3-A (Reference 3.3-7)."

- Add the following as the first equation in the first paragraph of Subsection 3.3.2.2.4:

"W_t = W_w"

- Add the following as the third, fourth, and fifth equations in the first paragraph of Subsection 3.3.2.2.4:

  "W_t = W_m

  W_t = $W_w + 0.5\ W_p$

  W_t = $W_w + W_m$"

- Add the following as the last reference in Subsection 3.3.4:

  "3.3-7 Tornado and Extreme Wind Design Criteria for Nuclear Power Plants, Bechtel Topical Report BC-TOP-3-A, Bechtel Power Corporation, San Francisco, California, Revision 3, August 1974."

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

4/9/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 218-1907 REVISION 0**
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QUESTION NO. RAI 3.3.2-04:

1. RAI Text

The US-APWR applicant indicates that wind loading for the Power Source Buildings (PS/Bs) is determined using ASCE/SEI 7-05, Method 1 and tornado wind loading for enclosed and partially enclosed buildings is determined using ASCE/SEI 7-05, Method 2. Based on these statements, it is not clear as to whether the PS/Bs are analyzed using Method 1 or Method 2.

Provide information about the method used by the applicant to determine wind loading effects for the PS/Bs including an assessment of whether the PS/Bs are classified as enclosed or partially enclosed buildings and whether or not the PS/Bs have openings capable of venting atmospheric pressure changes caused by passage of a tornado.

2. Concern

The applicability of using ASCE/SEI 7-05, Method 1 or Method 2 to determine wind loading effects on a particular structure depends on conditions described in ASCE/SEI 7- 05 Sections 6.4.1.1 and 6.5.1, respectively.

In order for the NRC staff to ensure that the safety of the PS/Bs is not compromised due to wind loading effects, the applicant is requested to provide information that explains which method will be used to determine the design wind loads for these structures. Additional information about the description of either Method 1 or Method 2, as appropriate, is requested to demonstrate compliance with GDC-2 in 10 CFR 50, Appendix A.

3. Applicant References

DCD Tier 2, Revision 1, Sections 3.3.1.2 and 3.3.2.2.1.

4. Context

Structural integrity of Seismic Category I structures, which assures that SSCs important to safety are protected, and not compromised according to GDC-2 in the Appendix A to Part 50 of 10 CFR.

5. Priority/Impact

Medium – information is essential to completing a technical review and resolving a safety issue. The review can continue, but cannot be completed without the requested additional information.

6. Dependencies

Internal – There are interfaces with SRP Chapter 3.0, Section 3.3.1.

External – There are no external dependencies.

ANSWER:

For basic wind loading, Method 1 of ASCE/SEI 7-05 Section 6.4 is used for the PS/Bs, as stated in DCD Subsection 3.3.1.2 and as further clarified in the response to RAI 215-1906, Question RAI 3.3.1-01. It should be noted that in ASCE/SEI 7-05 Commentary, Section 6.4, page 282, Method 1 is based on the low-rise procedure from Method 2, as shown in Fig. 6.10, for a specific group of buildings (simple diaphragm buildings). For tornado wind loading, Method 2 of ASCE/SEI 7-05 Section 6.5 is used as stated in DCD Subsection 3.3.2.2.1. Method 2 is chosen because it provides a more detailed and accurate procedure for determining wind pressures and resultant loading for the main wind-force resisting system from the tornado effects than Method 1. For example, the US-APWR maximum tornado wind speed exceeds the maximum basic wind speed shown in Figure 6-2 for ASCE/SEI 7-05 for Method 1, which could lead to questionable extrapolation if Method 1 is used. The adjustment factor λ used for Method 1 is also partially dependent on the effects of variation of wind speed with respect to building height, whereas the design basis tornado wind remains constant with height. Therefore, Method 2 is more appropriate for tornado wind loading analysis.

With respect to atmospheric pressure changes caused by passage of a tornado, the PS/Bs are designed as vented. DCD Subsection 3.3.2.2.2 will be revised accordingly to make this clarification.

Impact on DCD

See Attachment 1 for a mark-up of DCD Tier 2, Section 3.3, Revision 2, changes to be incorporated.

- Change the second and third sentences of the third paragraph of Subsection 3.3.2.2.2 to state: "This is the case for the PS/Bs, A/B, T/B, and AC/B, which are designed as vented structures. Where applicable, interior walls of the PS/Bs and A/B are designed considering tornado differential atmospheric pressure loading."

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

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

remains unchanged. The resulting outward differential pressure on the roof and exterior walls are applicable for all seismic category I unvented structures including the R/B (and its annulus which houses the containment penetration areas) and the PCCV.

For a structure that is partially enclosed or vented, the atmospheric pressure change occurs over a period of time, resulting in actual pressures less than or equal to the maximum pressure drop. This is the case for the PS/Bs, A/B, T/B, and AC/B, which are designed as vented structures. Where applicable, interior walls of the PS/Bs and A/B are designed considering tornado differential atmospheric pressure loading. The design of the T/B and AC/B are discussed further in Subsection 3.3.2.3.

The COL Applicant is to note the vented and unvented requirements of this subsection to the site-specific category I buildings and structures.

3.3.2.2.3 Tornado Missile Effects

Missiles generated by tornadoes are listed in Subsection 3.5.1.4 and barrier design for missiles is discussed in Subsection 3.5.3. The response of a structure or barrier to missile impact depends largely on the location of impact (e.g., midspan of a slab or near a support), on the dynamic properties of the target and missile, and on the kinetic energy of the missile. After it has been demonstrated that the missile will not penetrate the barrier, an equivalent static load concentrated at the impact area is then determined, from which the structural response, in conjunction with other design loads, is evaluated.

Overall effects of missile impact are designed for flexural, shear, and buckling effects on structural members using the equivalent static load obtained from the evaluation of structural response. The impact is assumed to be plastic, and ~~is~~ impact forces are determined as outlined in "Impact Effect of Fragments Striking Structural Elements" (Reference 3.3-6).

3.3.2.2.4 Combined Tornado Effects

The loading combinations of the individual tornado loading components are in accordance with SRP 3.3.2 (Reference 3.3-5) and are supplemented with the design criteria and procedures provided in BC-TOP-3-A (Reference 3.3-7). The total tornado wind load W_t, used in the load combinations discussed in Section 3.8, is determined for the combined effects using the following equations.

$$W_t = W_w$$

$$W_t = W_p$$

$$W_t = W_m$$

$$W_t = W_w + 0.5\, W_p$$

$$W_t = W_w + W_m$$

$$W_t = W_w + 0.5\, W_p + W_m$$

where

3.3-5 Tornado Loads, Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants, NUREG-0800, United States Nuclear Regulatory Commission Standard Review Plan 3.3.2, Revision 3, March 2007.

3.3-6 R.A. Williamson and R. R. Alvy, Impact Effect of Fragments Striking Structural Elements, Holmes and Narver, Inc. Publishers, November 1973.

3.3-7 Tornado and Extreme Wind Design Criteria for Nuclear Power Plants, Bechtel Topical Report BC-TOP-3-A, Bechtel Power Corporation, San Francisco, California, Revision 3, August 1974.