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June 6, 2008

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

Attention: Mr. Jefrey A. Ciocco,

Docket No. 52-021
MHI Ref: UAP-HF-08103

Subject: **MHI's Responses to US-APWR DCD RAI No.5**

References: 1) "Request for Additional Information No.5 Revision 0, SRP Section: 08.03.01 – AC Power Systems (Onsite), Application Section 8.3.1," dated May 7, 2008.

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.5 Revision 0."

Enclosed are the responses to 6 RAIs that are contained within Reference 1.

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

Sincerely,

Y. Ogata

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

1. Responses to Request for Additional Request No.5 Revision 0

CC: L. J. Burkhart
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Enclosure 1

UAP-HF-08103
Docket No. 52-021

Responses to Request for Additional Information No.5 Revision 0

June, 2008

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

6/6/2008

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.: NO.5 REVISION 0

SRP SECTION: 08.03.01 – AC Power Systems (Onsite)

APPLICATION SECTION: 8.3.1

DATE OF RAI ISSUE: 5/7/2008

QUESTION NO. : 08.03.01-1

RAI-08.03.01-001 In the SRP Section 9.5.6, "Emergency Diesel Engine Starting system," the starting air requirements are: As a minimum, the air starting system should be capable of cranking a cold diesel engine five times without recharging the receiver(s). The air starting system capacity should be determined as follows: (i) each cranking cycle duration should be approximately three seconds, (ii) consist of two to three engine revolutions, or (iii) air start requirements per engine start provided by the engine manufacturer, whichever air start requirement is larger. Since the GTGs are being proposed as class 1E power sources instead of diesel engines, they need to meet the same requirements. The applicant is requested to discuss the safety significance and provide bases why the 3 Air-start attempts are adequate for the GTG compared to 5 Air-starts required for the emergency diesel generators per SRP Section 9.5.6.

ANSWER:

1) NRC requirement
MHI assumes that the basis of the 5 times start requirement in the SRP section 9.5.6 is as follows:

- The requirement is based on a two (2) Class 1E train power distribution system plants.
- Each EDG should be tested separately. As a result, if one EDG is in testing, then one EDG is available to perform its safety function.
- For testing it is preferable that each EDG has sufficient air storage for a two (2) start capability.
- It is not required to assume that LOOP occurs during EDG testing. It is necessary to assume that LOOP occurs after the EDG testing completed.
- It takes a long time to fill the air receiver of the EDG. Air receiver should have enough capacity for a minimum three (3) starts in addition to above two (2) starts.

  Therefore, the EDG should be provided with sufficient air for a total of five (5) starts.

2) US-APWR design

The US-APWR is designed with four (4) 50% Class 1E GTGs. If one (1) GTG is in the test mode, the remaining three (3) GTGs can provide the plant safety function even considering a failure. Therefore, for each GTG is sufficient to have three (3) times start capability.

Furthermore, air compressors for the emergency power supply (EPS) are supplied power from the Class 1E 480V power system of respective train. When SBO occurs, non safety related AAC-GTG supply power to safety related power system included Class 1E 480V power system. Air compressors for EPS can be operated by non safety related AAC-GTG in order to recover from the SBO condition.

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

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US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.: NO.5 REVISION 0

SRP SECTION: 08.03.01 – AC Power Systems (Onsite)

APPLICATION SECTION: 8.3.1

DATE OF RAI ISSUE: 5/7/2008

QUESTION NO. : 08.03.01-2

RAI-08.03.01-002 The reliability analysis data provided in Section 7.0 of the "Qualification and test Plan of Class 1E Gas Turbine Generator System," comprises of 375 generator package units. The 375 generator package units consist of varying sizes with single and double gas turbines. The class 1E gas turbine generators (GTG) that are being proposed for the nuclear unit have dual turbines and are rated at 4500kW. Therefore, the reliability data provided in Section 7.0 of the Technical Report on GTG may not be directly applicable to the class 1E GTGs. The applicant is requested to provide a detailed breakdown comparison of the 375 GTG units with regard to size (kW), Starting method (air vs battery), components including number of turbines per generator and reliability data for each type and discuss how this data is applicable to the proposed class 1E GTGs. The applicant is requested to furnish run reliability data of GTGs that are similar to the GTGs proposed as class 1E power sources.

ANSWER:

1) Starting Reliability

The NUREG/CR-6928 issued by NRC has evaluated the component reliability of nuclear plant. EDG reliability is evaluated through collected data from 225 EDG units installed in US NPPs. These units are of different types, capacities and manufacturers. However, the starting reliability is evaluated using the sum of the total starts of each unit (24602 starts).
MHI's data "375units/7394starts" are collected from same product series. These units are of different types and capacities to each other. However, the design concept, design procedure and manufacturing are the same.

MHI believes that the provided data is sufficient to discuss EPS reliability.
However, to the extent possible, Table-1 below provides further data on the provided 375 generator package. These product series have experienced two starting failures. Also, the breakdown of "two failure experiences" are presented in Table-2.

Both of the failures were caused by failure of supporting system such as battery and fuel quality. To mitigate this, the US-APWR applies battery systems that are qualified under safety-related qualifications, and the fuel quality is to be controlled in accordance with nuclear requirements. As such these types of failures are to be prevented at US-APWR.
Furthermore, reliability of this data group is evaluated 4.0×10^{-4} /d. This is less than the EDG's reliability (5.0×10^{-3} /d) reported in NUREG/CR-6928.

Table-1

Data Group No.	Number of GTG Sets	Number of Failures/ Number of Starts	Type			
			Output (kVA)	Single engine or Twin engine	Fuel Type	Starting system
1	70	2/4891	150 to 300	Single	Diesel Oil	DC motor
2	19	0/2503	1000 to 1750	Single	Kerosene	DC motor
3	9		1000 to 1750	Single	Diesel Oil	DC motor
4	157		1000 to 1750	Single	Heavy Oil	DC motor
5	1		1000 to 1750	Single	Kerosene	Air
6	9		1000 to 1750	Single	Heavy Oil	Air
7	10		2000 to 4500	Twin	Kerosene	DC motor
8	5		2000 to 4500	Twin	Diesel Oil	DC motor
9	90		2000 to 4500	Twin	Heavy Oil	DC motor
10	5		2000 to 4500	Twin	Heavy Oil	Air

Table-2

	Product A	Product B
1. Output	250 kVA	150 kVA
2. Fuel Type	Diesel Oil	Diesel Oil
3. Starting Method	DC motor	DC motor
4. Delivered year	1983	1984
5. Total number of starting	119	76
6. Number of failure	1	1
7. Cause of failure	Low voltage by the battery degradation	The moisture mixing of liquid fuel

2) Running Reliability
The manufacturer performed standard running tests when the new lineup of this series was developed. The duration of this test is not determined, but test is done at least over 100 hours. This series was developed 21 types until this. In accordance with this, this series hasn't experienced running failure during 21000 hours.
NUREG/CR-6928 reports the EDG running reliability as 8.0×10^{-4} /hr. MHI believes this series has a good running reliability when compared with the EDGs used in US NPPs.

Operational experience of some the 185 units of this series, have experienced "Blackout" conditions due to snow, earthquake and transmission system failures. These GTG sets had to run from 2 to 38 hours after start, and did not experience failures. This GTG set series was developed as emergency (standby) generator sets. These products also have very good potential for high running reliability, based on the aero engine.

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

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US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.: **NO.5 REVISION 0**

SRP SECTION: **08.03.01 – AC Power Systems (Onsite)**

APPLICATION SECTION: **8.3.1**

DATE OF RAI ISSUE: **5/7/2008**

QUESTION NO. : 08.03.01-3

RAI-08.03.01-003 In Section 7.0 of the Qualification and test Plan of Class 1E Gas Turbine Generator System the stated reliability of the GTG is 99.9% based on the accumulative start data of the 375 units. As stated in the report, there were 7394 starts for the 375 units, or 19.7 starts per unit. For reliability calculations of individual units this is a very small number of starts. Based on the two failures cited in the report and assuming that these failures were on different GTGs, the reliability for these two GTG units would be 95% and not 99.9% as indicated in the report .The applicant is requested to discuss how the reliability data given in Section 7 of the report complies with the requirements of the IEEE-387 of 100 starts with no failures.

ANSWER:

The breakdown of the "two failure experiences" is shown in the following Table.

Table-2 (Repeated)

	Product A	Product B
1. Output	250 kVA	150 kVA
2. Fuel Type	Diesel Oil	Diesel Oil
3. Starting Method	DC motor	DC motor
4. Delivered year	1983	1984
5. Total number of starting	119	76
6. Number of failure	1	1
7. Cause of failure	Low voltage by the battery degradation	The moisture mixing of liquid fuel

1) MHI believes that our reliability evaluation is adequate as mentioned in the answer of question 08.03.01-2.

2) Both failures were caused by failure of the supporting system. The US-APWR will prevent such failure from the application of safety-related design to the supporting system.
3) The Manufacturer has performed 1000 start tests, as their standard procedure when the new lineup of this series was developed. Every new lineup is approved as after the completion of the 1000 start tests with no failure.
4) MHI believes this series product has good reliability. However, MHI has plans to perform the 100 start tests and show the result of the test so that these GTGs satisfy US nuclear requirements.

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.

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RAI NO.: **NO.5 REVISION 0**
SRP SECTION: **08.03.01 – AC Power Systems (Onsite)**
APPLICATION SECTION: **8.3.1**
DATE OF RAI ISSUE: **5/7/2008**

QUESTION NO. : 08.03.01-4

RAI-08.03.01-004 The applicant for USPWR has chosen to use IEEE-387 and NRC RG 1.9, documents that were written for qualifying emergency diesel generators (EDGs), since there are no industry standards or NRC guides for qualifying gas turbine generators as onsite Class 1E power sources. The current version of IEEE-387 calls for 100 starts with no failures for qualification of onsite class1E diesel generators However it should be understood that the earlier versions of IEEE-387 and NRC regulatory guides for qualifying EDGs as class 1E power sources used 300 starts with 3 failures. The majority of current fleet of US nuclear power plants used this criterion for qualifying EDGs. It was deemed prudent to relax the criterion of 300 starts to 100 starts because manufacturers of EDGs and the nuclear users of EDGs had gained considerable experience in the manufacturer, application and testing of the EDGs as applied Class1E power sources in nuclear power plants. As a comparison, there is no such experience base of GTG applications in nuclear power plants. The proposed GTG application as class 1E power sources for the USAPWR is first of a kind application in the world. The applicant is requested to justify and provide a basis why the qualification tests for the GTG should be less than 300 tests that were originally required for EDG qualification.

ANSWER:

MHI understands that the current regulation requires the 100 starts test in R.G 1.9/IEEE387-1995.
MHI would like NRC to clear the NRC's regulatory position about number of start test, firstly.
MHI understands IEEE387-1995 was revised from 300 starts to 100 starts based on the opinion of industries. The industries have informed their opinion to NRC that too much repeated starting test can't evaluate the reliability adequately and accurately. This is because repeated starting test cause engine wear and degradation. Consequently the test would not show accurate reliability of that engine.
Basically, MHI wants to follow the IEEE 387-1995.
However, if NRC requires a 300 starts test, we will do additional 200 starting tests as an optional reference test.
MHI's course of action will be decided after further discussions with the NRC.

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

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US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.: **NO.5 REVISION 0**

SRP SECTION: **08.03.01 – AC Power Systems (Onsite)**

APPLICATION SECTION: **8.3.1**

DATE OF RAI ISSUE: **5/7/2008**

QUESTION NO. : 08.03.01-5

RAI-08.03.01-005 The manufacturer published information on the allowable ambient temperature range for the GTG from 41 degrees F to 104 degrees F. The NEMA standard MG-1 "Motors and Generators" specifies the maximum ambient temperature of 40 degrees C (104F) without specifying the minimum temperature. The applicant is requested to discuss the significance of the lower range temperature on the performance of the GTG. Also, the applicant should discuss the derating factors associated with the GTG for locations where the ambient temperature may exceed the 104 degrees F.

ANSWER:

1) Allowable high side ambient temperature is determined to ensure the required engine output power, this is as the engine output power is decreases as ambient temperature increases. On the other hand, allowable low side ambient temperature is determined to ensure that every component performs normally.

2) The ambient temperature condition of US-APWR is set within -40 degrees F to 115 degrees F in the DCD. The Class 1E GTG of US-APWR can generate over 4500kW at 115 degrees F(Note1). In accordance with this, rated output of Class 1E GTG is determined to be 4500kW as standard design. If the US-APWR is constructed in a location where the high side ambient temperature is below 115 degrees F, the GTG will have more margin than standard design.

Note 1: a) Output of Gear-Box at 115 degrees F is 4766kW, b) Planned generator efficiency is more than 0.96, c) Generator output is 4766 × 0.96=4575kW

3) From the point of view of the low side ambient temperature, the most critical item is the characteristics of fuel oil, because fuel oil liquid is changed to mist for combustion. Each fuel oil such as Kerosene oil, Diesel oil and Heavy oil has its own Kinematic Viscosity. The Kinematic Viscosity should be below 10(cst). Generally, in the case of Kerosene oil, the GTG manufacturer recommends that the temperature of the fuel should be controlled over -13 degrees F in order to

maintain the Kinematic Viscosity below 10(cst). In the case of Diesel oil, GTG manufacturer recommends that the temperature of fuel should be controlled over 41 degrees F in order to maintain the Kinematic Viscosity below 10(cst). The standard design of US-APWR has the heating equipment as countermeasure against for low side ambient temperature.

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.

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US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No.52-021

RAI NO.: **NO.5 REVISION 0**

SRP SECTION: **08.03.01 – AC Power Systems (Onsite)**

APPLICATION SECTION: **8.3.1**

DATE OF RAI ISSUE: **5/7/2008**

QUESTION NO. : 08.03.01-6

RAI-08.03.01-006 In SECY-90-16, "Evolutionary Light Water Reactor(LWR) Certification Issues and Their Relationships to Current Regulatory requirements," the NRC Commissioners approved the staff's position that all evolutionary ALWR's have an AAC power source of diverse design capable of powering at least one set of normal shutdown loads. Also, RG1.206 provides guidance on meeting 10CFR50.63 (station Blackout rule) for evolutionary designs. Similar to SECY-90-16, it requires the installation of an AAC power source of diverse design with sufficient capacity, capability, and reliability that will be available on a timely basis for powering at least one complete set of normal safe shutdown loads (nondesign-basis accident) to bring the plant to safe shutdown. In SECY-91-078, item 5.2.3, "power Rating of the Combustion Turbine Generators," the staff concluded that, as a minimum, the GTG should be capable of powering one safety division and one division of permanent non-safety loads during worst-case shutdown (to cold shutdown) and that it should have capability to power these loads with some margin for load growth when operating within its continuous rating. In the USAPWR design, The GTG proposed for meeting 10CFR50.63 is rated at 4000kW and are of the same design and manufacture as the class 1E onsite GTG power sources. The applicant has claimed that AAC GTGs and class 1E GTGs are diverse because AAC GTGs use battery for starting whereas the class 1E GTGs use air starting. The applicant is requested to discuss and elaborate on limiting common mode failure potential in the safety and non-safety GTGs since they are of the same manufacture and design. Also, the applicant is asked to discuss whether the 4000kW GTG is sized to power one safety division and one division of permanent non-safety loads during worst-case shutdown (to cold shutdown) and that it has the capability to power these loads with some margin for load growth when operating within its continuous rating.

ANSWER:

1) MHI understands that NRC's regulatory position for SBO management is provided in R.G 1.155. In this guide, it's required that safe shutdown be maintained under the SBO condition in section 3.3.5 as follows. *"The AAC power source should have sufficient capacity to operate the systems necessary for coping with a station blackout for the time required to bring and maintain the plant in safe shutdown".*

The rating of AAC-GTG is determined such that the AAC-GTG can keep the unit at hot shut down condition by supplying power to one safety-related train.
Furthermore, US-APWR has two AAC-GTGs. Since two AAC-GTGs can be available under the SBO condition, the plant can be operated to the cold shut down condition. In order to operate the plant under this condition, about 7100kW (Please see DCD Section 8.3) is required as 100% load capacity. In comparison with this value, two AAC-GTGs capacity (i.e. 8000kW) has sufficient margin.
MHI believes US-APWR satisfy with NRC's regulatory position and SECY's recommendation for evolutionary NPPs.

2) US-APWR applies the same manufacturer's products on both Class 1E GTG engine and non Class 1E AAC-GTG engine.
However, MHI designs to limit the common mode failure potential as a minimum between Class 1E GTG and non Class 1E AAC-GTG shown in Table-4.

Table-4

	Class 1E GTG	AAC-GTG
1. Rated Output	4500kW	4000kW
2. Generator	Different Manufacture	
3.Starting method	Air motor	DC motor
4.Fuel system	Almost same design concept, but independent completely	
5. DC power source for starting and control component	Class 1E plant battery (vented type)	Special installed non safety-related battery (VRLA type)
6.Location	Different Room	
7. AC power source for supporting component	Class 1E power system	Non Class 1E power system

In addition, all supporting components and equipment such as sensors, control equipment and motors also have diversity because of difference of QA quality (Class 1E and non Class 1E).

Based on experiences of EPS's failure, MHI believes that providing diversity for supporting system components and equipment as much as possible is very important to prevent CMF.

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.