Enclosure 3

UAP-HF-08122
Docket Number 52-021

Responses to Request for Additional Information No.8 Revision 0

July 2008
(Non-Proprietary)

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

7/10/2008

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

RAI NO.:	**NO.8 REVISION 0**
SRP SECTION:	**08.03.02 – DC POWER SYSTEMS (ONSITE)**
APPLICATION SECTION:	**08.03.02**
DATE OF RAI ISSUE:	**6/10/2008**

QUESTION NO. : 08.03.02-2

RAI-SRP 8.3.2-EEB-01
Section 8.3.2.1.1,"Class 1E DC Power System," of the FSAR discusses the adequacy of the Class 1E DC power systems. Provide additional information in the following areas:

a. Inverter specification including voltage regulation, frequency variation, and total Harmonic distortion (THD)

b. Regulating transformer specifications including voltage regulation

c. UPS protective scheme against faults (e.g., overcurrent, fault current, undervoltage,underfrequency)

ANSWER:

a) Class 1E Inverter (UPS unit)

The detail design of UPS unit depends on actual procurement specification. However, MHI plans to apply the Class 1E UPS unit which has following specifications shown in Table 1. Though following specifications include some manufacture's standard specifications, following UPS unit satisfies with requirement from load design condition.

Table 1

Item	Specification
1. Rectifier Unit	
1) Input nominal voltage	3 phase, 480V
2) Input operating range	408V to 552V
3) Frequency	60Hz +/-10%
4) Nominal DC voltage	125V
5) Rectifier type	12 pulse
2. Inverter Unit	
1) DC input	125V +/-20%
2) Nominal AC voltage	120V
3) Output voltage (static)	< +/-1%
4) Output voltage (dynamic)	< +/-2%
5) Frequency tolerance without main	+/-1%
6) Voltage distortion	=/<3%

b) Transformer

The power source of each Class 1E I&C power supply system consists of both UPS unit and transformer. This transformer is not automatic voltage regulating type.
The detail design of transformer depends on actual procurement specification. However, MHI plans to apply the Class 1E I&C power transformer which has following specification shown in Table 2.

Table 2

Item	Specification
1) Rating	50 kVA
2) Input	Single phase, AC 480V
3) Output	Single phase, AC 120V
4) Tap	Primary side: 440V, 460V, 480V, 500V, 520V

c) Protection scheme

The detail design of protection scheme depends on actual procurement specification. However, MHI will determine the detail design in accordance with IEEE-446 and recommendation from manufactures.
The fault current, over current, overvoltage and undervoltage are basic protection schemes. In addition an inverter is also commonly supplied with current-limiting capability for protection. Distribution devices are to be coordinated with this inverter's current-limiting capability.

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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QUESTION NO. : 08.03.02-3

RAI-SRP 8.3.2-EEB-02
It is stated in Section 8.3.2.1.1 of the FSAR that each Class 1E battery charger has the capacity to recharge its battery from the design minimum charge to a 95% charged condition within 24 hours and simultaneously supply the normal dc loads of the associated 125V dc switchboard bus. However, the staff notes that the each non-Class 1E battery charger has the capacity to recharge its battery from the design minimum charge to fully charged condition within 24 hours and simultaneously supply the normal dc loads of the associated 125V dc switchboard bus. Provide your justification for not providing the Class 1E battery chargers enough capacity to recharge their batteries from the design minimum charge to fully charged condition rather than to a 95% charged condition.

ANSWER:

The first paragraph of page 8.3-44 of DCD Section 8.3.2.1.2 describes that each non safety Class 1E battery charger is designed to charge fully within 24 hours. This description is to be revised. Each non safety Class 1E battery charger is designed to charge the battery to 95% capacity within 24 hours. MHI will revise the DCD.

The battery chargers of US-APWR are designed in accordance with IEEE-946. The IEEE-946 accepts the design that charger has capability to charge 95% capacity within 8 to 24 hours. MHI evaluates the battery sizing by using condition of 95% charging capability of charger. Please see the answer of 08.03.02-8.

Therefore the battery chargers of US-APWR are designed to have sufficient capacity. Detail evaluation of charger and battery sizing is provided in Attachment B.

Impact on DCD

MHI will revise the first paragraph description of page 8.3-44 of Section 8.3.2.1.2 of DCD Revision 1, “fully” to “95%”.

Impact on COLA

There is no impact on COLA.

Impact on PRA

There is no impact on PRA.

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QUESTION NO. : 08.03.02-4

RAI-SRP 8.3.2-EEB-03
It is stated in Section 8.3.2.1.1 of the FSAR that there are four Class 1E safety battery chargers: one for each train, connected to the Class 1E 125V dc switchboard bus. In addition, there are two installed non-Class 1E spare battery chargers, one spare battery charger AB for trains A and B, and another spare battery charger CD for trains C and D. The spare battery charger AB can be used to temporarily replace any one of the Class 1E battery chargers A or B. Similarly, the spare battery charger CD can be used to temporarily replace any one of the Class 1E battery chargers C or D. The non-Class 1E spare battery charger is placed in service to temporarily replace any one of the four inoperable Class 1E chargers. Provide your justification for replacing Class 1E battery chargers with non-Class 1E chargers when Class 1E chargers are inoperable during power operation. In addition, describe the periodic surveillances that will be performed on the non-Class 1E battery chargers.

ANSWER:

There are two non Class 1E spare battery chargers AB and CD. The non Class 1E spare battery charger AB is replaced Class 1E charger A or B, and non Class 1E spare charger CD is replaced Class 1E charger C or D during maintenance of these Class 1E chargers.

US-APWR has four 50% safety-related trains for the DC systems. Even if one of these systems is in maintenance outage, safety function of plant can be achieved by three remaining systems.
However, it is preferred that spare charger is used to prevent the dry out of battery from view point of system availability during of maintenance of Class 1E charger.

When the Class 1E charger is in maintenance, respected Class 1E DC system is in out of service condition. Therefore, the spare battery charger is not required as safety-related design and also periodic surveillance like Class 1E charger's is not required.

Each spare charger connects to two trains' DC switchboards through the two MCCBs in the spare charger unit. These two MCCBs in the spare charger unit don't close simultaneously because of key interlock of MCCBs. This circuit prevents that both Class 1E trains' DC switchboards connecting to each other.
And each Class 1E switchboard has two incoming MCCBs, one from respected Class 1E charger and other from spare charger. These MCCBs don't close simultaneously because of key interlock of MCCBs. This circuit prevents each Class 1E DC switchboard from being supplied power from both of Class 1E charger and non-Class 1E spare charger simultaneously.
Above MCCBs are controlled by manual except for automatic trip by fault current.

Detail of maintenance program of Class 1E charger and non Class 1E spare charger will be determined in consideration of manufacture's recommendation.

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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QUESTION NO. : 08.03.02-5

RAI-SRP 8.3.2-EEB-05
It is stated in Section 8.3.2.1.1 of the FSAR that the Class 1E switchboards employ molded case circuit breakers and/or fusible disconnect switches as input and output circuit protection devices. Confirm whether it is going to be molded circuit breakers or fusible disconnect switches as input and output circuit protection devices. If molded circuit breakers are used, describe how the molded case circuit breakers will be coordinated with the downstream protective devices. In addition, provide results of the coordination studies performed on the dc system.

ANSWER:

The standards such as IEEE-946 provide the typical design guidance. Both MCCB and fuse are accepted as protective device in those standards.

Basically, protective coordination is designed between incoming protection device and feeder protecting devices in switchboard. The detail design of protection devices and switchboard system will be determined in consideration of actual procurement specification.

However, MHI evaluates that protection coordination can be achieved between incoming protection device and feeder protecting devices in Class 1E switchboard. Incoming device of Class 1E battery needs approximately 2000A, fuse is used typically in excess of 2000A. This main fuse can be coordinated with feeder MCCBs adequately.

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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QUESTION NO. : 08.03.02-6

RAI-SRP 8.3.2-EEB-06
It is stated in Section 8.3.1.1.6 of the FSAR that in case of failure of the UPS unit or if the UPS
unit is out on maintenance, buses A, B, C and D are switched to the 50kVA, 480V/120V ac bypass transformer associated with the same train. Switching between each UPS unit and the bypass transformer is done automatically by an undervoltage signal. Describe in detail how this circuitry works and where the undervoltage signal is derived from.

ANSWER:

The input power of each Class 1E 120V panelboard can be switched between UPS unit side and transformer side at the switching circuit. This is performed automatically through an undervoltage relay in the switching circuit.
A panelboard is supplied power from UPS unit side normally. A contactor of UPS unit side is closed, and a contactor of transformer side is opened normally. When the input power from UPS unit side is lost, undervoltage relay actuates. And a contactor of UPS unit side is opened, and then a contactor of transformer side is closed with time delay.

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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QUESTION NO. : 08.03.02-7

RAI-SRP 8.3.2-EEB-07

Figure 8.1-1 of the FSAR shows that the A MOV MCC1, A MOV MCC2, B MOV MCC, C MOV MCC, D MOV MCC1 and D MOV MCC2 are fed from the corresponding train of the MOV inverter each of which is backed up by the pertinent Class 1E 125V dc bus. Confirm that the batteries and battery chargers have sufficient capacity to provide backup power for the additional inverter load while carrying its own design basis loads.

ANSWER:

Figure 8.3.2-1 of DCD shows the configuration of Class 1E DC system. A MOV inverter 1 and A MOV inverter 2 are supplied power from A DC switchboard via the A1 DC switchboard normally. Also, A MOV inverter 1 and A MOV inverter 2 can be supplied power from B DC switchboard via the A1 DC switchboard. B MOV inverter is supplied power from B DC switchboard normally. And also, B MOV inverter can be supplied power from A DC switchboard. Situation of train C and D MOV inverters is similar to train A & B.

This means that each train battery supplies power to maximum three MOV inverters. MHI designs that each train battery can supply to loads which includes the three MOV inverters.

MHI requires the capacity over 5000AH for all train battery as mentioned in Table 8.3.2-3 in DCD.

Table 8.3.2-1 (sheet 1 of 4) in DCD, current of A MOV inverter 1440A is total current of A MOV inverter 1, A MOV inverter 2 and B MOV inverter. On the other hand, current of B MOV inverter 720A in Table 8.3.2-1 (sheet 2 of 4) is current of only B MOV inverter. MHI will revise the current of MOV inverter of "sheet 2 of 4" and "sheet 3 of 4" to 1440A.

MHI provides the detail of battery sizing analysis in Attachment B.

Impact on DCD

MHI will revise the DCD Revision 1 that loads condition of Table 8.3.2-3 replace to condition of Table 8.3.2-B2 in Attachment B of this RAI report.

Impact on COLA

There is no impact on COLA.

Impact on PRA

There is no impact on PRA.

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QUESTION NO. : 08.03.02-8

RAI-SRP 8.3.2-EEB-08
The staff notes that the battery sizing includes only 10 percent design margin. IEEE std. 485 recommends a design margin of 10-15% capacity margin to allow for unforeseen additions to the dc system and less-than-optimum operating conditions of the battery due to improper maintenance, recent discharge, or ambient temperature lower than anticipated or a combination of these factors. Since the battery chargers are sized to carry the normal dc system load and simultaneously recharge a design basis discharged battery to 95 % of full rated capacity, the staff is concerned that when battery is declared operable at 95 % of the full rated capacity it will have only 5% margin available for load growth. Justify that 10% instead of 15% margin for load growth is adequate in your design when battery is supplying power at 95 % of the full rated capacity.

ANSWER:

Class 1E battery size and charger size are designed in accordance with IEEE Std. (IEEE-485, IEEE-946).
MHI designs that each Class 1E battery has minimum 10% margin. And also Class 1E charger is designed which has capability of 95% charging within 24hr.

The detail of evaluation is provided Attachment B.
For example, each Class 1E battery is evaluated 4560AH as minimum rating including 10% margin, 25% aging factor and 95% initial capacity. Typical battery rating is determined in accordance with manufacturer's standard. MHI selects and applies 5100AH battery. It has enough margins. And also charger size is calculated by using this battery rating 5100AH.

MHI believes the charger has sufficient margins.

Impact on DCD

There is no impact on DCD.

Impact on COLA

There is no impact on COLA.

Impact on PRA

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QUESTION NO. : 08.03.02-9

RAI-SRP 8.3.2-EEB-09

It is stated in Section 8.3.2.1.1 of the FSAR that the instrumentation and control (I&C) power supply system inverters are designed to supply 120 V ac power with dc input less than 140V and more than 108 V. I&C power supply system inverters are powered from dc switchboard and are capable of operating at the battery minimum terminal voltage of 108 V. Since, there will be some voltage drop from the battery terminal to the inverter terminal, explain how the voltage will be maintained more than 108V at the inverter terminal.

ANSWER:

The Class 1E batteries are designed under the condition of 1.8V as minimum battery terminal voltage per one cell (108V per system). MHI will apply the UPS unit which has more than 100V as specification of minimum acceptable DC input voltage (125V +/-20%). It has also been evaluated that voltage drop of Class 1E UPS unit can be kept less than 8V (Please see Attachment B).

Table 3

Mode	Class 1E DC system voltage	DC input voltage of Class 1E UPS unit
1. Period of equalizing charging to battery	140V; at output terminal of charger	132V; at input terminal of UPS unit
2. Period of end portion of battery discharging	108V; at output terminal of battery	100V; at input terminal of UPS unit

The above statement of DCD means that Class 1E UPS unit is to be designed to cope with 108V as battery terminal voltage. However, above statement is not an appropriate description. MHI will revise the DCD statement.

Impact on DCD

MHI will revise the description in Section 8.3.2.1.1 of DCD Revision 1, 108V is battery terminal voltage.

Impact on COLA

There is no impact on COLA.

Impact on PRA

There is no impact on PRA.

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QUESTION NO. : 08.03.02-10

RAI-SRP 8.3.2-EEB-10
It is stated in Section 8.3.2.1.1 of the FSAR that the battery rooms are ventilated to the outside air to preclude a hydrogen concentration of more than 2%. A safety-related ventilation system is not directly required when the batteries perform their safety function. Clarify why operability of the safety-related ventilation system is not required when the batteries perform their safety function.

ANSWER:

US-APWR applies safety-related ventilation system to the Class 1E battery room. To control the hydrogen concentration is the most important function of ventilation system required. The function of preventing hydrogen concentration of ventilation system is designed in accordance with R.G 1.128.
Hydrogen concentration control comes into play only when the battery is being charged. MHI states above DCD description that safety function of battery is under the condition of discharging and supplying power to loads.

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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QUESTION NO. : 08.03.02-11

RAI-SRP 8.3.2-EEB-11
Table 8.3.2-1,"125 V DC Class 1E Load Current Requirement," of the FSAR provides current requirement of 438 amps for a UPS unit in all columns of the table. Since the battery voltage decreases after one minute and reduces to 108V after two hours, shouldn't the dc input current for the UPS increase as the battery input voltage to the UPS decreases?

ANSWER:

When the AC input power of a Class 1E charger is lost, the Class 1E battery starts to discharge and supply DC power to DC loads including Class 1E UPS unit. The voltage of a battery decreases gradually during discharge. DC input current of UPS unit increases in accordance with decreasing of battery voltage because UPS unit will maintain the output power against the decreasing of input voltage. MHI evaluates the DC input current of UPS unit as conservative by using worst current condition.

MHI will apply the UPS unit which has more than 100V as specification of acceptable DC input voltage (125V +/- 20%). The rating of Class 1E UPS unit is 50kVA. MHI evaluates the current by using minimum acceptable voltage as follows.

$$50 \times 0.7 \div 0.8 \div 0.1 = 437.5(\mathrm{A})$$

- 50(kVA) : rating of UPS unit
- 0.7: Average power factor of digital I&C loads
- 0.8: Efficiency of UPS unit
- 0.1: 100V minimum acceptable voltage of UPS unit

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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QUESTION NO. : 08.03.02-12

RAI-SRP 8.3.2-EEB-12
Table 8.3.2-1 of the FSAR shows current requirement of 1 amp for Class 1E 480V Load Center. This appears to be too low. Provide your basis for providing 1 amp for Class 1E 480V Load Center. In addition, the staff finds that this table does not include current requirements for loads such as load sequencer, dc solenoids, ground detector, auxiliary relays, indicating lights etc. Confirm that all the loads listed above are included in battery load calculations.

ANSWER:

The load current of load depends on actual procurement specification. However, MHI evaluates the DC system analysis in case of load centers with air circuit breakers. The result of analysis and evaluation is shown in Attachment B.

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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QUESTION NO. : 08.03.02-13

RAI-SRP 8.3.2-EEB-13
Table 8.3.2-1 of the FSAR shows the current requirement of 10 amps for emergency lighting. Confirm that the above current value includes emergency lighting for the main control room as well as the remote shutdown console.

ANSWER:

Based on the following preliminary calculations, 10-Ampere from each Class 1E dc system for emergency dc lighting in the MCR and Remote Shutdown console (RSC) is adequate.

Calculations: (The detail of calculation is shown in Attachment A)

Room Dimensions as per Reference Drawing US-APWR Standard Plant Reactor Building

MCR dimensions are approximately 63 ft x 36 ft

RSC room dimensions are approximately 16 ft x 15 ft

Minimum Emergency lighting required in the MCR and RSC is 10FC (100 lumens/ m2).

Fluorescent lamps are considered for the emergency lighting.

The attached lighting calculations show the requirement of 12 – 57W fluorescent lamp fixtures for providing emergency lighting in the MCR and RSC.

Considering 57W per for each fluorescent fixture, the total load requirement is 12 x 57W = 684W on the dc system. These 12 fixtures are distributed on two trains of the dc system in order to assure the minimum required illumination level with a postulated failure of the other two trains. Hence, the total emergency lighting load on each dc system is (684 / 2) = 342W or 3.1A at 110V ac or 2.7 A at 125 V dc. Use of ac or dc lighting fixtures will be decided during the detail design phase. If ac fixtures are used, inverters for lighting circuits will be required. Considering an worst-case inverter efficiency of 70%, the load on the dc system is (342 / 0.7 / 125) = 3.9 A at 125 V dc.

Hence, 10 ampere on each train of the emergency dc system as shown in Table 8.3.2-1 of the DCD is more than adequate to provide minimum design basis illumination level in the MCR, RSC and the passage in between MCR and RSC.

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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QUESTION NO. : 08.03.02-14

RAI-SRP 8.3.2-EEB-14
In order for staff to assess the adequacy of the safety related dc power systems, provide the results of battery sizing calculations, battery terminal voltage calculations, short circuit calculations, and voltage drop calculations for staff review.

ANSWER:

The result of analysis and evaluation are shown in Attachment B.

MHI will carry the evaluation and analysis as actual plant design of MHI. The detail data will not be available because the design documents include the proprietary information.

However, MHI provides to NRC this Attachment B which is summary of evaluation and analysis of Class 1E DC system as reference information for RAI response.

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.

Attachment A

LIGHTING CALCULATIONS FOR US-APWR EMERGENCY DC LIGHTING REQUIREMENTS

ROOM DESCRIPTION AND /OR NUMBER	REFLECTANCES			DESIGN FC	ROOM L	ROOM W	ROOM AREA	MTG HEIGHT	CAVITY HEIHGT	RCR	FIXT TYPE	FIXT MARK	CU	LLF	LAMP TYPE	LAMP LUMENS	LAMPS/ FIXTURE	FIXT REQD	FIXT USED	ACTUAL FC
	CEILING	WALL	FLOOR																	
Main Control Room (MCR)	0.7	0.5	0.2	10	63	36	2268	12	9	1.96	2 SP G 2 32 A12125 120 GEB	Lithonia	0.78	0.69	T8-32W	2850	2	7.4	10	13.5
Remote Shutdown Console (RSC)	0.7	0.5	0.2	10	16	15	240	12	9	5.81	2 SP G 2 32 A12125 120 GEB	Lithonia	0.5	0.69	T8-32W	2850	2	1.2	2	16.4

$$NUMBER\ OF\ LUMINARES = \frac{FC * AREA}{(LUMENS\ PER\ LAMP) * (NUMBER\ OF\ LAMPS\ PER\ LUMINARE) * CU * LLF}$$

$$NUMBER\ OF\ LAMPS = \frac{FC * AREA}{(LUMENS\ PER\ LAMP) * CU * LLF}$$

$$ACTUAL\ FC = \frac{NUMBER\ OF\ FIXTURES\ USED}{NUMBER\ OF\ FIXTURES\ REQUIRED} * DESIGN\ FC$$

$$RCR = \frac{5 * CAVITY\ HEIGHT * (L + W)}{AREA}$$

$$RR = \frac{AREA}{(W * H) * (L + W)}$$

AREA: MCR, RSC & Passage
DESIGNED BY: ________ DATE: ________
CHECKED BY: ________ DATE: ________

SHEET 1 OF 1 SHEETS

FC = FOOT CANDLES
RCR = ROOM CAVITY RATIO
RR = ROOM RATIO
LLF = LIGHT LOSS FACTOR

ROOM CAVITH HEIGHT = LUMINARE TO WORK PLANE

CELL SHADED IN LIGHT YELLOW ARE FOR USER INPUT DATA, CLEAR CELLS ARE PROTECTED CALCULATIONS.

THE LIGHT LOSS FACTOR IS OBTAINED BY MULTIPLYING THE FOLLOWING:
BALLAST FACTOR (0.95), LAMP LUMEN DEPRICIATION (0.85), LUMINARE DIRT DEPRECIATION (0.9), AND ROOM DIRT DEPRECIATION (0.95). USING THESE NUMBERS YOU GET A LLF= 0.69.

Attachment B