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TOKYO, JAPAN

December 18, 2013

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

Attention: Mr. Perry Buckberg

Docket No. 52-021
MHI Ref: UAP-HF-13312

Subject: **MHI's Revised Response to US-APWR DCD RAI No. 1017-7058 Question 08.02-17 (SRP 08.02)**

References: 1) "Request for Additional Information No. 1017-7058, SRP Section: 08.02 – Offsite Power System, Application Section: 8.2," dated April 1, 2013.
2) Letter MHI Ref. UAP-HF-13106 from Y. Ogata to U.S. NRC, "MHI's Response to US-APWR DCD RAI No.1017-7058 (SRP 08.02)," dated May 10, 2013.

With this letter, Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") a document entitled "Revised Response to Request for Additional Information No. 1017-7058 Question 08.02-17."

Enclosed is the revised response to Question 08.02-17 contained within Reference 1. The original response to Question 08.02-17 was previously submitted to the NRC in Reference 2. The response was revised to address NRC feedback provided to the industry during a public meeting on November 1, 2013. This revised response supersedes the previous response.

Please contact Mr. Joseph Tapia, General Manager of Licensing Department, 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,
Executive Vice President
Mitsubishi Nuclear Energy Systems, Inc.
On behalf of Mitsubishi Heavy Industries, LTD.

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Enclosure:

1. Revised Response to Request for Additional Information No. 1017-7058 Question 08.02-17

CC: P. Buckberg
J. Tapia

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Enclosure 1

UAP-HF-13312
Docket No. 52-021

Revised Response to Request for Additional Information
No. 1017-7058 Question 08.02-17

December 2013

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

12/18/2013

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.: **NO. 1017-7058**

SRP SECTION: **08.02 - OFFSITE POWER SYSTEM**

APPLICATION SECTION: **8.2**

DATE OF RAI ISSUE: **4/01/2013**

QUESTION NO. : 08.02-17

On July 27, 2012, the NRC issued Bulletin 2012-01, "Design Vulnerability in Electric Power System," (Agencywide Documents Access and Management System (ADAMS) Accession Number ML12074A115) to all holders of operating licenses and combined licenses for nuclear power reactors requesting information about the facilities' electric power system designs. This Bulletin was issued in light of the recent operating experience that involved the loss of one of the three phases of the offsite power circuit (single-phase open circuit condition) at Byron Station, Unit 2 to verify compliance with applicable regulations and to determine if further regulatory action is warranted.

In order to verify that the applicant has addressed the design vulnerability identified at Byron in accordance with the requirements specified in General Design Criterion (GDC) 17, "Electric Power Systems," in 10 CFR Part 50, Appendix A, "General Design Criteria for Nuclear Power Plants," and the design criteria for protection systems under 10 CFR 50.55a(h)(3), please provide the following information:

1. Describe the protection scheme design for important to safety buses (non-safety or safety-related) to detect and automatically respond to a single-phase open circuit condition or high impedance ground fault condition on credited offsite power circuits.

2. If the important to safety buses are not powered by offsite power sources during at power condition, explain how the surveillance tests are performed to verify that a single-phase open circuit condition or high impedance ground fault condition on an off-site power circuit is detected.

3. Describe how the plant operating procedures, including off-normal operating procedures, specifically call for verification of the voltages on all three phases of the ESF buses.

If the DCD applicant understands that this design vulnerability should be addressed by the COL applicants, please provide the appropriate COL item that requests the COL applicants to address the issues stated in Bulletin 2012-01.

ANSWER:

Protection Scheme Design:

Consistent with the current licensing basis and the requirements of GDC 17, electrical protective devices will detect design basis conditions, such as an undervoltage (UV) (loss of voltage or a degraded voltage) condition. However, the electrical protective devices are not designed to detect an open phase condition or an open phase condition with a high impedance ground fault condition, on credited offsite power circuits. The current status of the US-APWR UV protection design scheme is described below.

The US-APWR design consists of four Class 1E power system trains. The medium voltage (MV) bus of each train has a protection scheme that protects against operating in an UV condition. The primary side of each of three instrument potential transformers (PTs) is connected phase-to-phase in a "delta" configuration. A UV relay is connected to the secondary side of each PT. Two-out-of-three logic automatically initiates transferring the Class 1E buses from the normal offsite power circuit to the alternate offsite power circuit. If the alternate offsite power circuit is not available, a bus transfer to a Class 1E gas turbine generator will be initiated.

The design of the US-APWR electrical system does not provide quantitative information for detecting an open phase condition or an open phase condition with a high impedance ground fault for each plant operating condition. A qualitative assessment during a heavy loading condition of the reserve auxiliary transformers (RATs), which normally supply the Class 1E buses, shows that an open phase condition or an open phase condition with a high impedance ground fault on an offsite power circuit may possibly be detected by UV protection using two-out-of-three logic. The qualitative assessment, during a heavy loading condition, of the unit auxiliary transformers (UATs), which alternatively supply the Class 1E buses in a back-feeding condition from the grid, shows that an open phase condition or an open phase condition with a high impedance ground fault, on an offsite power circuit, may possibly be detected. Conditions for normal plant operations are such that the main generator supplies power to the non-safety (and not important to safety) MV buses via the UATs. If an open phase condition or an open phase condition with a high impedance ground fault on the high voltage side of the main transformer (MT) occurs when the Generator Load Break Switch (GLBS) is closed, the main generator will be tripped by the generator protection equipment. Additionally, if the Class 1E buses are powered via the UATs during this condition, the Class 1E buses are properly protected and are automatically transferred to Class 1E GTGs. However, during normal plant operations, the RATs serve only safety-related loads resulting in light loading of the RATs. This condition may result in insufficient UV for detection by UV protection, in an open phase condition at the high voltage side of the RATs.

Based on the assessment for the current US-APWR design, design improvement is incorporated by following the "Open Phase Condition Initiative" document which is issued by NEI to address the issues raised by NRC Bulletin 2012-01. MHI will change the protection scheme design of the offsite power circuits by adding dedicated detection device(s) for open phase condition on the high voltage side of the RATs and MT so that the detection device(s) can detect an open phase condition on the high voltage side of the transformers, with or without grounding. An alarm is initiated in the MCR for open phase conditions and the offsite power circuit supplying the Class 1E buses is isolated and automatically transferred to another offsite source or to a Class 1E GTG, upon detection of the open phase condition in all plant operating conditions. This design change also includes detection of a two phase open condition, with or without grounding.

The type of detection device(s) will be identified considering site specific offsite power system configuration in the site-specific detailed design phase, consistent with the industry schedule described in the NEI "Open Phase Condition Initiative". Surveillance requirements such as channel calibration, channel check, setpoint verification, etc. are required to ensure the protection. Surveillance requirements will be provided when with detection device(s) have been determined. Therefore, an additional COL Item will be added to the DCD to address these surveillance requirements.

Important to Safety Buses:

As described in DCD Subsection 8.1.2.2, the US-APWR ESF buses are powered by offsite power sources, via the RATs; therefore, surveillance tests to detect an open phase condition, or an open phase condition with a high impedance ground fault are not required.

Operating Procedures:

The plant operating procedures, including off-normal operating procedures, will be provided in accordance with COL Items in DCD Section 13.5.

Impact on DCD

DCD Tier 1 and Tier 2 Chapters 1 and 8 will be revised as shown in the attached markups.

DCD Tier 2 Chapter 19 will be revised when the PRA model is revised. If the components are identified as risk-significant based on the PRA results, the components will be added to DCD Table 17.4-1.

Impact on R-COLA

The R-COLA will be updated to be consistent with the DCD revision, including the addition of the new COL item.

Impact on PRA

The design change will be reflected in the US-APWR PRA when the PRA is revised.

Impact on Technical / Topical Reports

There is no impact on technical / topical reports.

1. The functional arrangement of the ac electrical power systems is as described in the Design Description of Subsection 2.6.1.1 and as shown in Figure 2.6.1-1.

2. Independence is provided between each division of the four divisions of the Class 1E distribution equipment and circuits, and between Class 1E distribution equipment and circuits and non-Class 1E distribution equipment and circuits.

3. Independence between Class 1E electric power distribution equipment and non-Class 1E loads is provided by Class 1E qualified isolation devices.

4. Class 1E electric power distribution equipment of redundant divisions, identified in Table 2.6.1-1, is located in separate rooms in the reactor building.

5. Deleted.

6.a The seismic Category I Class 1E ac electrical power system equipment, identified in Table 2.6.1-1, can withstand seismic design basis loads without loss of safety function.

6.b If power through the RATs is not available, each Class 1E medium voltage bus is automatically transferred to the UATs, if available.

6.c If both offsite power sources are not available, each Class 1E medium voltage bus automatically connects to its respective EPS.

6.d <u>If an open phase condition exists at the offsite power system, each Class 1E medium voltage bus is automatically transferred to its respective UAT.</u> DCD_08.02-17 S01

7. For all plant trip conditions, except for a trip due to electrical fault in either MT, MG, GLBS, UATs, or associated equipment and circuits, the GLBS opens.

8. For electrical fault in either MT, MG, GLBS, UATs, or associated equipment and circuits, the MT circuit breaker at the switchyard opens.

9. Deleted

10. The UATs and RATs power sources are sized for worst case loading conditions for all modes of plant operation and accident conditions.

11.a The Class 1E distribution equipment and circuits are sized to carry the worst case load currents, to withstand the maximum fault currents, and to provide minimum design basis voltage at load terminals to support accomplishment of their safety functions.

11.b The Class 1E cables are sized considering derating due to ambient temperature and raceway loading.

12. The interrupting ratings of the Class 1E circuit breakers and fuses are adequate for maximum available fault currents.

13. The MT, UATs, and RATs have their own fire deluge system, oil pit and drain system.

Table 2.6.1-3 AC Electric Power Systems Inspections, Tests, Analyses, and Acceptance Criteria (Sheet 2 of 8)

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
	6.a.ii Type tests, analyses or a combination of type tests and analyses of seismic Category I Class 1E ac electrical power system equipment identified in Table 2.6.1-1, will be performed using analytical assumptions, or will be performed under conditions, which bound the seismic design basis requirements.	6.a.ii A report exists and concludes that the seismic Category I Class 1E ac electric power system equipment identified in Table 2.6.1-1, can withstand seismic design basis loads without loss of safety function.
	6.a.iii Inspection and analysis will be performed to verify that the as-built seismic Category I Class 1E ac electrical power system equipment identified in Table 2.6.1-1, including anchorages, is seismically bounded by the tested or analyzed conditions.	6.a.iii A report exists and concludes that the as-built seismic Category I Class 1E ac electric power system equipment identified in Table 2.6.1-1, including anchorages, is seismically bounded by the tested or analyzed conditions.
6.b If power through the RATs is not available, each Class 1E medium voltage bus is automatically transferred to the UATs, if available.	6.b A test will be performed to verify that each as-built Class 1E medium voltage bus is automatically transferred to the UAT when UAT power is available upon simulated loss of power from the RAT.	6.b Each as-built Class 1E medium voltage bus is automatically transferred to the UAT when power through the RATs is not available and power is available at the UAT.
6.c If both offsite power sources are not available, each Class 1E medium voltage bus automatically connects to its respective EPS.	6.c A test will be performed to verify that each as-built Class 1E medium voltage bus automatically connects to the respective EPS upon simulated loss of power from the RAT and UAT.	6.c Each as-built Class 1E medium voltage bus automatically connects to its respective EPS if both offsite power sources are not available.
6.d If an open phase condition exists at the offsite power system, each Class 1E medium voltage bus is automatically transferred to its respective UAT.	6.d A test will be performed of the four as-built Class 1E medium voltage buses to verify that each Class 1E medium voltage bus is automatically transferred to its respective UAT, upon an actual or simulated open phase signal of the detection device(s) of the as-built RATs.	6.d Upon receipt of an actual or simulated open phase signal of the detection device(s) of the as-built RATs, each as-built Class 1E medium voltage bus is automatically transferred to its respective as-built UAT.

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Table 1.8-2 Compilation of All Combined License Applicant Items for Chapters 1-19 (Sheet 18 of 38)

COL ITEM NO.	COL ITEM
COL 8.2(5)	*The COL Applicant is to provide detail description of alternate preferred power.*
COL 8.2(6)	*Deleted*
COL 8.2(7)	*The COL Applicant is to address protective relaying for each circuit such as lines and buses.*
COL 8.2(8)	*The COL Applicant is to address switchyard dc power as part of switchyard design description.*
COL 8.2(9)	*The COL Applicant is to address switchyard ac power as part of switchyard design description.*
COL 8.2(10)	*The COL Applicant is to address transformer protection corresponded to site-specific scheme.*
COL 8.2(11)	*The COL Applicant is to address the stability and reliability study of the offsite power system. The stability study is to be conducted in accordance with BTP 8-3 (Reference 8.2-17). The study should address the loss of the unit, loss of the largest unit, loss of the largest load, or loss of the most critical transmission line including the operating range, for maintaining transient stability. A failure modes and effects analysis (FMEA) is to be provided.* *The grid stability study shows in part that, with no external electrical system failures, the grid will remain stable and the transmission system voltage and frequency will remain within the interface requirements (±10% for voltage and ±5% for frequency) to maintain the RCP flow assumed in the Chapter 15 analysis for a minimum of 3 seconds following reactor/turbine generator trip.*
COL 8.2(12)	*Deleted*
COL 8.2(13)	*The COL Applicant is to provide surveillance requirements for the device(s) used to detect open phase condition on the high voltage side of the RATs and MT, with or without grounding.*
COL 8.3(1)	*The COL Applicant is to provide transmission voltages. This includes also MT and RAT voltage ratings.*
COL 8.3(2)	*The COL Applicant is to provide ground grid and lightning protection.*
COL 8.3(3)	*The COL Applicant is to provide short circuit analysis for ac power system, since the system contribution is site specific.*
COL 8.3(4)	*Deleted*
COL 8.3(5)	*Deleted*
COL 8.3(6)	*Deleted*
COL 8.3(7)	*Deleted*
COL 8.3(8)	*The COL Applicant is to provide short circuit analysis for dc power system.*
COL 8.3(9)	*Deleted*
COL 8.3(10)	*The COL Applicant is to provide protective device coordination.*

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emergency shutdown of the plant due to any electrical fault in the 26 kV system or associated equipment and circuits, the fault is isolated by opening the main circuit breaker on the high voltage side of the MT and all incoming circuit breakers of the MV buses connected to the UAT power source; and all affected MV buses are automatically transferred to the RAT source. The MV Class 1E buses are not affected since these are normally fed from the RATs. The UAT incoming breakers to these buses is locked out and blocked from closing.

Unit synchronization is normally through the GLBS. Synchrocheck relays are used to ensure proper synchronization of the unit to the offsite power system.

High voltage circuit breakers are sized and designed in accordance with IEEE Std C37.010 and C37.06 (Reference 8.2-14, 8.2-15). High voltage disconnecting switches are sized and designed in accordance with IEEE Std C37.32 (Reference 8.2-16).

The MTs, UATs and RATs have differential, over-current, sudden pressure and ground over-current protection schemes per IEEE Std 666 (Reference 8.2-9). The COL Applicant is to provide site-specific protection scheme.

Detection device(s) are provided on the high voltage side of the RATs and MT, respectively, to address the NRC Bulletin 2012-01 (Reference 8.2-18). The detection device(s) detect open phase condition on the high voltage side of the RATs and MT, with or without grounding. An alarm is initiated in the MCR for open phase and the offsite power circuit to Class 1E buses is isolated and transferred to another offsite power source or to a Class 1E GTG automatically upon detection of the open phase condition. The COL Applicant is to provide the required surveillance requirements for the device(s) used to detect open phase condition, with or without grounding. DCD_08.02-17 S01

Isolated phase busduct provides the electrical interconnections between generator load terminals to the GLBS, the GLBS to the MT and the disconnect links on the high voltage side of the UATs, and the UAT disconnect links to the UATs. Non-segregated phase bus ducts/cable buses provide electrical connections between the low voltage side of the UATs and RATs to the 13.8 kV and 6.9 kV MV switchgear. The non-segregated phase bus ducts/cable buses from the UATs and RATs are physically separated to minimize the likelihood of simultaneous failure.

Each of the single phase transformers of the MT is provided with disconnect links so that a failed transformer may be taken out of service and the spare transformer can be connected. All UATs are also provided with disconnect links so that a failed transformer can be taken out of service. With one UAT or one RAT out of service, all MV buses will have access to at least one offsite power source.

[[The MT, UATs and RATs are located in the transformer yard adjacent to the turbine building (T/B), and the RATs are separated from the MT and the UATs by 3-hour rated fire barriers.]] Cables associated with the normal preferred and alternate preferred circuits are physically separated from each other to minimize common cause failure[[, even supposing that these circuits share a common underground duct bank]]. In accordance with the guidance of Generic Letter 2007-01, for preventing the degradation of medium voltage cables that are installed in underground duct banks, the manholes are at the low point with the conduits in the connecting duct banks sloped for water drainage into the

8.2.4 Combined License Information

COL 8.2(1) *The COL Applicant is to address transmission system of the utility power grid and its interconnection to other grids.*

COL 8.2(2) *Deleted*

COL 8.2(3) *The COL Applicant is to address the plant switchyard which includes layout, control system and characteristics of circuit breakers and buses, and lightning and grounding protection equipment.*

COL 8.2(4) *The COL Applicant is to provide detail description of normal preferred power.*

COL 8.2(5) *The COL Applicant is to provide detail description of alternate preferred power.*

COL 8.2(6) *Deleted*

COL 8.2(7) *The COL Applicant is to address protective relaying for each circuit such as lines and buses.*

COL 8.2(8) *The COL Applicant is to address switchyard dc power as part of switchyard design description.*

COL 8.2(9) *The COL Applicant is to address switchyard ac power as part of switchyard design description.*

COL 8.2(10) *The COL Applicant is to address transformer protection corresponded to site-specific scheme.*

COL 8.2(11) *The COL Applicant is to address the stability and reliability study of the offsite power system. The stability study is to be conducted in accordance with BTP 8-3 (Reference 8.2-17). The study should address the loss of the unit, loss of the largest unit, loss of the largest load, or loss of the most critical transmission line including the operating range, for maintaining transient stability. A failure modes and effects analysis (FMEA) is to be provided.*

The grid stability study shows in part that, with no external electrical system failures, the grid will remain stable and the transmission system voltage and frequency will remain within the interface requirements (±10% for voltage and ±5% for frequency) to maintain the RCP flow assumed in the Chapter 15 analysis for a minimum of 3 seconds following reactor/turbine generator trip.

COL 8.2(12) *Deleted*

COL 8.2(13) *The COL Applicant is to provide surveillance requirements for the device(s) used to detect open phase condition on the high voltage side of the RATs and MT, with or without grounding.* DCD_08.02-17 S01

8.2-17 Stability of Offsite Power Systems, BTP 8-3, March 2007.

8.2-18 Design Vulnerability in Electrical Power System, NRC BULLETIN 2012-01, July 2012. DCD_08.02-17 S01