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

Attention: Mr. Jeffrey A. Ciocco

Docket No. 52-021
MHI Ref: UAP-HF-11295

Subject: MHI's Revised Response to US-APWR DCD RAI No. 687-5394 Revision 2 (SRP 15.0.0.7 and 8.2.3)

References:
1) "REQUEST FOR ADDITIONAL INFORMATION 687-5394 REVISION 2" dated January 27, 2011 (ML110280035).
2) "MHI's Response to the US-APWR DCD RAI No. 687-5384 Revision 2 (SRP 15.0.0.7 and 8.2.3)", MHI Letter UAP-HF-11049, dated February 25, 2011 (ML110601195).

Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") the document entitled "MHI's Revised Response to US-APWR DCD RAI No. 687-5394 Revision 2 (SRP 15.0.0.7 and 8.2.3)". In Reference 2, MHI provided the response to the NRC's Request for Additional Information ("RAI") in Reference 1. MHI has revised the response to Question 15.0.0-24 of Reference 2 based on prior discussion in conference calls between MHI and the NRC. The material in Enclosure 1 provides MHI's revised response to the NRC's "Request for Additional Information (RAI) 687-5394," dated January 27, 2011. The response in Enclosure 1 supersedes the previous response provided in Reference 2.

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.

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Enclosures:

1. MHI's Revised Response to US-APWR DCD RAI No. 687-5394 Revision 2 (SRP 15.0.0.7 and 8.2.3) (non-proprietary)

CC: J. A. Ciocco
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ENCLOSURE 1

UAP-HF-110295
Docket No. 52-021

MHI's Revised Response to US-APWR DCD RAI No. 687-5394
Revision 2 (SRP 15.0.0.7 and 8.2.3)

September 2011

(Non-Proprietary)

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

9/09/2011

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 687-5394 REVISION 2**
SRP SECTION:	**15 – INTRODUCTION – TRANSIENT AND ACCIDENT ANALYSES)**
APPLICATION SECTION:	**15.0.0.7 and 8.2.3**
DATE OF RAI ISSUE:	**1/27/2011**

QUESTION NO.: 15.0.0-24

The NRC staff notes that there is an inconsistency between Chapter 8 and Chapter 15 with respect to the basis for the 3 second time delay between a reactor trip and the loss of offsite power (LOOP). Per DCD Section 15.0.0.7, the safety analyses assume that a LOOP occurs a minimum of 3 seconds after a reactor/turbine trip to account for the time it would take for grid instability, caused by the turbine-generator trip, to propagate through the grid to the plant offsite power source. However, Section 8.2.3 states that in the event of a LOOP concurrent with reactor/turbine trip, the main generator remains connected to the grid powering reactor coolant pumps (RCPs) thru the UATs and that the large inertia of the turbine–generator will maintain voltage and frequency for more than 3 seconds.

Remove the apparent inconsistency between Chapter 8 and chapter 15 and provide the following:

a) If the statement in Section 8.2.3 provides the relied-upon basis, describe in detail how the large inertia of the turbine generator would maintain adequate voltage and frequency to the RCPs for an additional 3 seconds, assuming that a LOOP occurs concurrently with a reactor/turbine trip. The staff is concerned that during this event the main generator would attempt to power the grid and may not be able to support adequate voltage and frequency for the RCPs for 3 seconds to satisfy the Chapter 15 safety analysis assumptions. Therefore, the applicant needs to show that adequate voltage and frequency will be maintained during this scenario before the generator is separated from the grid.

b) If the statement in Section 15.0.0.7 of the DCD provides the relied-upon basis, provide an analysis that demonstrates that a LOOP occurs a minimum of 3 seconds after a reactor/turbine trip to support this assumption. As part of this analysis, provide the basis for the conclusion that this is a bounding situation given the site-specific nature of such analysis.

ANSWER:

The safety analyses in DCD Chapter 15 consider a LOOP as part of a plant transient in two ways:

1) The LOOP is the initiating event.
2) The LOOP occurs as a secondary effect during the transient as a result of grid disturbances caused by a turbine generator trip.

In the first case, where the LOOP is the initiating event, this event is explicitly analyzed in DCD Subsection 15.2.6. In the Subsection 15.2.6 safety analysis, the RCPs are assumed to trip (and begin to coast down) at the same time as the LOOP (no delay). In this case, there is no 3 second delay period credited. Therefore, there is no required relied-upon basis for the assumption in Subsection 15.2.6.

The second case, where the LOOP is a secondary event during the transient, pertains to DCD Section 15.0.0.7. The RCPs may receive electrical power from either the turbine generator or the offsite power grid. Certain Chapter 15 events result in a reactor trip. A reactor trip causes a turbine generator trip. It is assumed that this turbine generator trip could cause a grid disturbance which could ultimately result in a LOOP. This scenario would result in a loss of electrical power to the RCPs and a loss of flow transient would begin in addition to the initiating event. When applying this scenario to the Chapter 15 events, the safety analyses assume that electrical power to the RCPs can be maintained to the RCPs for at least 3 seconds following the turbine generator trip. The RCPs are assumed to continue to run during this 3 second period and provide normal RCS flow. The description in Subsection 15.0.0.7 was intended to explain this assumption and provide the basis. However, the information in Subsection 15.0.0.7 was not intended to describe the detailed design of the electrical distribution system. That information is more appropriately described in DCD Chapter 8. Therefore, Subsection 15.0.0.7 will be revised to describe the 3 second assumption used in the safety analyses and to explicitly refer to Chapter 8 for the relied-upon basis for the 3 second assumption. The changes to DCD Chapters 8 and 15 are shown in the "Impact on DCD" section below. "Figure-1 Generator Circuit Interlock Diagram" is attached below to supplement the information about the impact on DCD Chapter 8.

Impact on DCD

DCD Subsection 15.0.0.7 will be revised as indicated in the mark-up in Attachment 1.

The third paragraph of DCD Subsection 8.2.3 and COL Item 8.2(11) will be revised as indicated in the mark-up in Attachment 2.

Impact on R-COLA

There is no impact on the R-COLA.

Impact on S-COLA

There is no impact on the S-COLA.

Impact on PRA

There is no impact on the PRA.

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

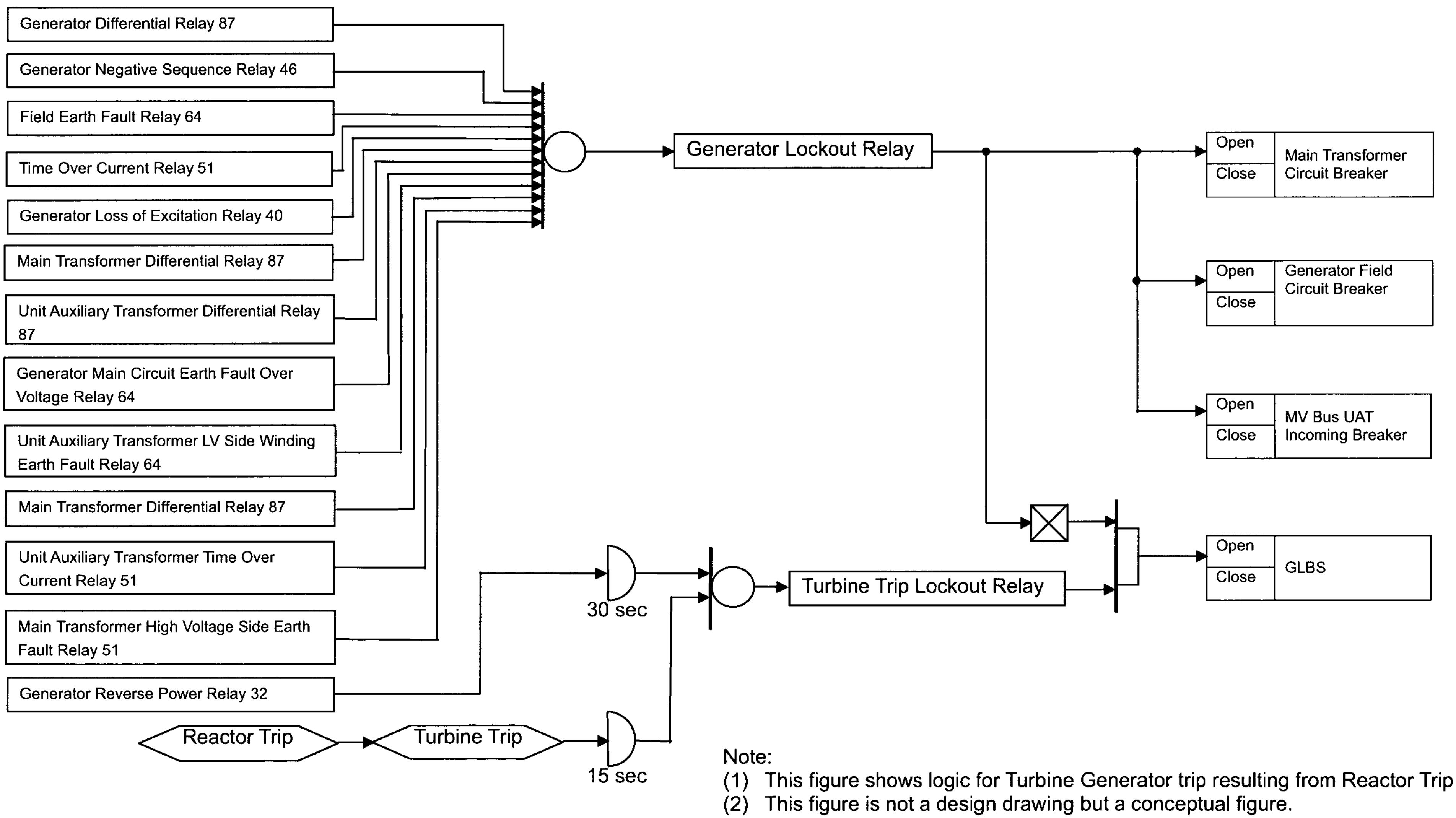

Figure-1 Generator Circuit Interlock Diagram

After some events, however, the fault that initiated the trip also renders certain equipment unavailable or ineffective after the trip (such as when the initiating event for the transient involves a break in the RCS, the feedwater system, or the steam system piping). The actions taken following these transients, and the time at which these actions occur, depend on what systems are available and the plans for post-transient plant operation.

For all shutdowns, decay heat must be removed through the steam generators to maintain a stable hot standby condition.

In addition, for all shutdowns from power, if a hot standby condition is maintained for an extended time, operator action may be required to add boric acid through the chemical and volume control system (CVCS) or ECCS with emergency letdown to compensate for xenon decay, which could otherwise reduce shutdown margin.

Operator actions required to mitigate accidents are described in the individual event evaluation sections. The non-LOCA events whose analyses credit operator actions are inadvertent dilution of boron concentration in the RCS (Section 15.4.6)~~, CVCS malfunction that increases RCS inventory (Section 15.5.2)~~, and steam generator tube failure (Section 15.6.3). The radiological consequence events whose analyses credit operator actions are RCCA ejection (Section 15.4.8) and failure of small lines carrying primary coolant outside containment (Section 15.6.2). In addition, operator actions are credited to prevent boric acid precipitation to assure post-LOCA long term cooling (Section 15.6.5). DCD_16-298

15.0.0.7 Loss of Offsite AC Power

The analyses for AOOs and other accidents consider transients both with and without offsite power available for cases where the event may be accompanied by a turbine-generator trip. Since all reactor trips are accompanied by a turbine trip, this extends to all events resulting in a reactor trip. This analysis approach is consistent with 10 CFR 50, Appendix A, General Design Criteria (GDC) 17 (Ref. 15.0-12). DCD_15.0.0-24 S01

The unavailability of offsite power is not considered in characterizing the frequency of the event sequence (i.e., for transients that are AOOs, the AOO acceptance criteria are applied even when the offsite power is considered to be unavailable).

The loss of offsite power is considered in addition to the limiting single failure assumed for the event sequence where offsite power is available.

The US-APWR is designed such that the source of electrical power for the RCPs can be the plant generator or offsite power. As described above, the Chapter 15 events consider a loss of offsite power (LOOP) for all events that lead to a turbine generator trip. This LOOP along with the turbine generator trip would result in the loss of electrical power to the RCPs. The RCPs would then coast down, resulting in a loss of flow transient in addition to the initiating event. The accident analyses assume a LOOP occurs a minimum of 3 seconds after the reactor/turbine generator trip. A turbine generator trip without a prior reactor trip is also assumed to have the same 3-second delay time. The basis for this 3-second delay is provided in DCD Subsection 8.2.3. DCD_15.0.0-24 S01

~~The US-APWR is designed such that the normal source of electrical power for the RCPs is the plant generator. The plant design incorporates a time delay between turbine and generator trips, allowing power to the RCPs to be maintained for a period of time following a turbine trip. This design feature is conservatively ignored in the accident analyses. The reactor trip causes a turbine trip, which then causes a generator trip. The generator trip is assumed to cause a disturbance in the utility grid, which is conservatively assumed to cause a loss of offsite power (LOOP). The accident analyses assume a loss of offsite power occurs a minimum of 3 seconds after the reactor trip. This 3-second delay accounts for the time it would take for a grid instability caused by the turbine-generator trip due to the reactor trip to propagate through the grid to the plant offsite power source. A turbine-generator trip without a prior reactor trip is also assumed to ultimately cause a LOOP with the same 3-second delay time.~~ DCD_15.0.0-24 S01

~~The principal concern with a LOOP occurring at the time of reactor trip is that a complete loss of flow transient would be superimposed on the initiating event. With the beginning of the reactor coolant pump coastdown delayed more than 3 seconds after reactor trip,~~ The 3-second delay assumption ensures that the RCPs remain running for at least 3 seconds after the reactor/turbine generator trip. This means that the rods are inserted to the dashpot by the time the LOOP (and corresponding loss of flow) is initiated. (Refer to Figure 15.0-3) This time delay between the reactor trip and pump coastdown assures that the portion of the transient following a postulated LOOP occurs after the limiting DNBR. Therefore, the minimum DNBR at any time during the transient is the same with offsite power available or unavailable. For this reason, the LOOP cases following reactor trip are not presented in each of the event-specific analyses.

For peak pressure analyses, the time assumed for the loss of offsite power with respect to the reactor or turbine-generator trip is not a key parameter. The assumed time for the loss of offsite power is described in the applicable DCD Chapter 15 subsection.

15.0.0.8 Long Term Cooling

The reactor trip and ESF actuation systems are designed to mitigate accident conditions and to stabilize the plant at hot standby conditions. After the plant has been stabilized the operators may continue to maintain the plant at hot standby or transition to and maintain the plant at cold shutdown conditions. In either case, adequate core cooling must be maintained to assure residual heat removal.

The residual heat removal system (RHRS) is designed to remove heat energy from the core and the RCS during shutdown and refueling conditions. Section 5.4.7 provides a detailed description of the US-APWR RHRS and safe shutdown operation. The RHRS consists of four independent subsystems (flow paths), each containing a containment spray/residual heat removal (CS/RHR) heat exchanger, a CS/RHR pump, and associated piping and valves. The CS/RHR heat exchangers and the CS/RHR pumps have functions in both the containment spray system (CSS) and the RHRS.

During system operation, each CS/RHR pump takes suction from one of the RCS hot legs by a separate suction line, and discharges through its respective CS/RHR heat exchanger. The reactor coolant is then returned to the RCS cold legs.

US-APWR design provides second level of undervoltage protection with time delays to protect the Class 1E equipment from sustained undervoltages.

8.2.3 Design Bases Requirements

The offsite power system of the US-APWR reference plant is based on certain design bases (as defined in 10 CFR 50.2 (Reference 8.2-13)) requirements.

The COL Applicant is to provide failure modes and effects analysis (FMEA) of offsite power system for conformance with following requirements.

- The normal and alternate preferred power supply circuits originating from separate transmission substations connect to the onsite ac power system, through the plant switchyard(s). Both circuits may share a common switchyard. The normal preferred circuit and the alternate preferred circuit are electrically isolated and physically independent from each other to the extent practical to minimize common mode failure. Each circuit is capable of supplying all unit auxiliary and service loads during normal plant power operation, as well as during normal or emergency shutdown.

- In case of failure of the normal preferred power supply circuit, the alternate preferred power supply circuit remains available.

- The switchyard buses to which the main offsite circuits are connected shall be arranged as follows:

  - Any incoming or outgoing transmission line for one circuit can be switched without affecting the other circuit.

  - Any circuit breaker can be isolated for maintenance without interrupting service to these circuits.

The RCP motors are connected to the non-Class 1E 6.9 kV buses. These buses are normally powered by the UATs. The offsite power system is connected to the turbine generator through the main transformer and the GLBS. When the GLBS is closed, the turbine generator provides power to the non-Class 1E 6.9 kV buses via the UATs. When the GLBS is open, the offsite power system provides power to the non-Class 1E 6.9 KV buses via the UATs. DCD_15.0.0-24 S01

The accident analyses in Chapter 15 consider a loss of offsite power (LOOP) for all events that lead to a turbine generator trip. In these events, the analyses assume that a LOOP occurs a minimum of 3 seconds after the turbine generator trip. The power supply to RCPs is assumed to be maintained for at least 3 seconds under the various unit trip conditions. The basis for the assumption regarding RCP power supply during the 3-second delay is as follows:

When a reactor/turbine trip occurs, the turbine trip signal is actuated to trip the main generator and open the GLBS. Prior to the GLBS opening, the generator will motor at a synchronous speed governed by the grid frequency. Since the generator remains connected to the UATs, the RCPs are powered by the generator. Therefore, power to the

RCPs will be maintained as long as the generator is motoring on the offsite power grid. The time delay between the reactor/turbine trip and the main generator trip/GLBS opening is set as 15 seconds. The reverse power relay is provided to protect the generator from motoring. It trips the generator and opens the GLBS after a 30 second delay from its actuation. The time delay is set within the permissible time for anti-motoring protection (maximum about one minute). The 30 second anti-motoring protection time delay serves as a backup to the 15 second reactor/turbine trip time delay in opening the GLBS. However, neither of these timers are credited in the Chapter 15 analyses. After the generator trips and the GLBS opens, the RCPs will be powered directly by offsite power through the UATs. As a result of this design, the RCPs will be continuously powered following a reactor/turbine trip for as long as offsite power is maintained. Since the stability of the offsite power is expected to be maintained for at least 3 seconds, this ensures the power supply to the RCPs assumed in the Chapter 15 analyses, regardless of the time delay between the reactor/turbine trip and the main generator trip/GLBS opening or the time delay for reverse power relay. The interface requirement for offsite power is maintaining a transmission system operating voltage of ±10% and a frequency of ±5% at the interface point between the transmission and offsite power system as defined in DCD Section 8.1.2.2. The COL Applicant is to perform the grid stability analysis to confirm this interface requirement. DCD_15.0.0-24 S01 DCD_15.0.0-24

When the initiating event of a unit trip is an electrical fault such as the failure of the isolated phase bus, the main transformer circuit breakers opens and the non-Class 1E 6.9 kV buses are switched over to be powered via the RATs by fast transfer. Therefore, the RCPs would be continuously supplied with power. DCD_15.0.0-24 S01

The above electrical design and configuration ensures power to RCPs for more than 3 seconds when a unit trip occurs.~~Transmission system stability is consistent with the condition of the transient and accident analysis in Chapter 15. It is assumed that the power supply to RCPs following a reactor/turbine trip is maintained at least 3 seconds by the main generator (turbine generator coast down) or the offsite power in Chapter 15. Following a reactor/turbine trip, stability of the offsite power is expected to be maintained, including the power supply to the RCPs. In addition, when the offsite power is lost concurrent with a reactor/turbine trip, the turbine-generator is still connected to the UATs and RCPs are powered by turbine-generator. The large inertia of the turbine-generator will maintain voltage and frequency more than 3 seconds. In case of a unit trip due to an electrical fault, the main transformer circuit breaker opens and the non-Class 1E buses are powered continuously via RAT. The interface requirement for offsite power is maintaining a transmission system operating voltage of ±10% and a frequency of ±5%. The COL Applicant is to perform grid stability analysis to confirm the assumption in Chapter 15.~~ DCD_15.0.0-24 DCD_15.0.0-24 S01

Transmission system reliability is consistent with the condition of the probability risk analysis of Chapter 19. The COL Applicant is to confirm transmission system reliability.

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. DCD_15.0.0-24

COL 8.2(12) *Deleted*

8.2.5 References

8.2-1 IEEE Standard General Requirements for Liquid-Immersed Distribution,