RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**61-7984**
SRP Section:	**08.03.01 – AC Power Systems (Onsite)**
Application Section:	**8.3.1**
Date of RAI Issue:	**07/06/2015**

Question No. 08.03.01-5

In Section 8.3.1.1, page 8.3.1-1, of the DCD Tier 2, the applicant states that "The COL applicant is to provide and to design a mobile generator and its support equipment (COL 8.3.1)." The staff notes that approximate sizing information of certain major equipment is provided. It appears that the sizing criteria for the mobile generator equipment and determining the design details are left for the Combined Operating License (COL) applicants to decide based on site specific information. However, the applicant has not provided any design aspects, including physical location, connection configuration, the method of transferring the source to safety buses, specification of the equipment, details of support equipment, and the methodology to determine the capacity of the mobile generator for its intended function during loss of all AC power in the scenario of a beyond design basis external event.

Provide a summary of the design aspects of the mobile generator, including anticipated physical location, connection configuration, the method of transferring the source to safety buses, specification of the equipment, details of support equipment.

Please discuss the methodology to determine the capacity of the mobile generator to show it can complete its intended function during loss of all AC power in the scenario of a beyond design basis external event.

Response

The following provides a summary of design aspects of the mobile gas turbine generators (GTGs) and the methodology to determine the capacity of GTGs.

The APR1400 engages two types of mobile GTGs to cope with each phase of mitigation strategies for beyond-design-basis external events (BDBEEs). Two redundant (N+1 requirement) 480V and one 4.16 kV mobile GTG are credited to power the Class 1E load center (LC) and switchgear (SWGR), respectively.

The details of the mitigation strategies for BDBEEs are provided in DCD Tier 2, Section 19.3 and Technical Report APR1400-E-P-NR-14005-P, Evaluations and Design Enhancements to Incorporate Lessons Learned from Fukusima Dai-Ichi Nuclear Accident.

In DCD Tier 2, each related section of Chapter 8 will be revised as shown in the attachment to describe the details of the mitigation strategies for BDBEEs.

<u>Anticipated physical location of the mobile GTGs</u>

As mentioned in DCD Tier 2, Subsection 19.3.2.3.4, details of the storage location for FLEX, including mobile GTGs, are to be addressed by the COL applicant (COL 19.3(4)).

The 480V mobile GTGs are located onsite and the 4.16 kV mobile GTG is mobilized from offsite.

The storage location of the 480V mobile GTGs will consider probable flooding levels at the site in the event of natural flooding due to rainfall or breakdown of a nearby dam, or tsunamis as applicable. The flood requirements for wet sites are also to be addressed by the COL applicant (COL 19.3(2)).

As stated in DCD Tier 2, Subsection 8.3.1.1, connection boxes are provided for each connection between the mobile GTGs and the Class 1E LC or SWGR buses in the entry and exit of the auxiliary building; hence, the mobile GTGs will operate near the connection boxes.

The storage location of the 480V mobile GTGs will also consider accessibility (i.e., moving routes) to the connection box.

<u>Connection configuration</u>

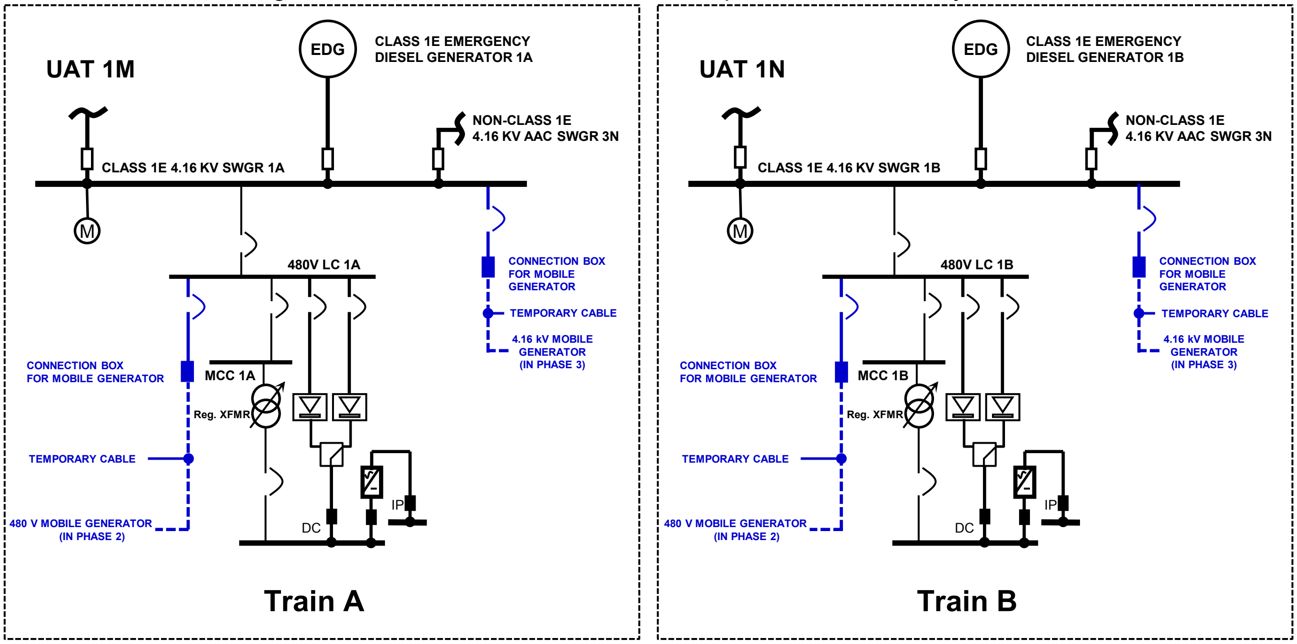
Class 1E loads are divided into two redundant load groups (Divisions I and II). Each division has two independent subsystem trains: trains A and C (Division I) and trains B and D (Division II). The mobile GTGs are connected to the Class 1E power system train A or B at each phase of the mitigation strategies for BDBEEs.

- Phase 2 : 480V mobile GTG connected to the LC bus
- Phase 3 : 4.16 kV mobile GTG connected to the SWGR bus

The mobile GTGs supply power to the Class 1E bus through connection boxes. Power cables between the connection boxes and the incoming circuit breakers of the Class 1E buses are permanent installations. Connections between the mobile GTGs and the connection boxes are implemented by temporary cabling.

To illustrate the preceding, a simplified single-line diagram is provided below.

< The mobile generators are connected to Class 1E power distribution system train A or B.>



Method of transferring the source to safety buses

Transfer of each mobile GTG to a Class 1E bus (480V LC or 4.16 kV SWGR) is implemented in the following manner:

1) Connection of loads

   - Shed all connected loads at the bus and then connect the loads to be supplied from the mobile GTG.

2) Transport of mobile GTG and temporary cables

   - Transport the mobile GTG and temporary cables near the connection box located in the entry and exit of the auxiliary building

3) Connection of temporary cables and ground cables

   - Connect temporary cables to the connection box and ground cables to the ground pad near or inside the auxiliary building

4) Starting mobile GTG

   - Place the starting switch to the “START" position at the local control panel of the mobile GTG

   - Verify the generator rated output voltage (±10%) and frequency (±2%) at the local control panel of the mobile GTG

5) Closing output breaker of mobile GTG and incoming circuit breaker (CB) of Class 1E buses

- Place the output breaker switch to the "CLOSE" position at the local control panel of the mobile GTG
- Close the incoming CBs to the Class 1E buses
- Verify the buses voltage (±10%) and frequency (±2%) at the MCR

A detailed procedure will be established by the COL applicant in the framework of mitigation strategies for BDBEEs which are addressed by COL 19.3(5).

<u>Specification of the equipment and details of support equipment</u>

As stated in COL item 8.3(1), detailed design of the mobile GTGs including support equipment (fuel oil transfer, cooling, lubrication, starting equipment, etc.) and specification of the equipment is in the scope of the COL applicant.

The COL applicant may choose state-of-the-art technologies and technical specifications suitable for the site conditions and the parameters and required function of the mobile GTGs.

Fuel oil supplied to the mobile GTGs is provided from existing onsite EDG fuel oil storage tanks.

<u>Methodology to determine the capacity of the mobile GTGs</u>

As described in DCD Tier 2, Section 19.3, two types of mobile GTGs are considered for mitigation strategies for BDBEEs as follows:

- To cope with Phase 2 of mitigation strategies for BDBEEs, two 480V mobile GTGs are provided.
- To cope with Phase 3 of mitigation strategies for BDBEEs, one 4.16 kV mobile GTG is provided.

DCD Tier 2, Subsection 19.3.2.3.1.1 (full-power operation) describes the scenario of a loss of offsite power (LOOP) with concurrent loss of all ac power and loss of normal access to the ultimate heat sink (LUHS).

Under this operation scenario, two redundant 480V mobile GTGs are each credited to power the Class 1E 480V load center loads during Phase 2 and the 4.16 kV mobile GTG is credited to power the Class 1E switchgear loads during Phase 3.

Considering the required loads during Phase 2 and Phase 3, loading of the 480V mobile GTGs and the 4.16 kV GTG was evaluated as shown in Table 5-5 of the Technical Report APR1400-E-P-NR-14005-P (Rev. 0). Selected ratings of the 480V mobile GTGs and the 4.16 kV mobile GTG are 1,000 kW and 5,000 kW, respectively.

A detailed breakdown of the electrical loading of the 480V mobile GTGs and the 4.16 kV mobile GTG are provided in Appendix C of Technical Report APR1400-E-P-NR-14005-P.

Impact on DCD

DCD Tier 2 Figure 8.1-1, Section 8.3 and Figure 8.3.1-1 will be revised as shown in the Attachment.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.

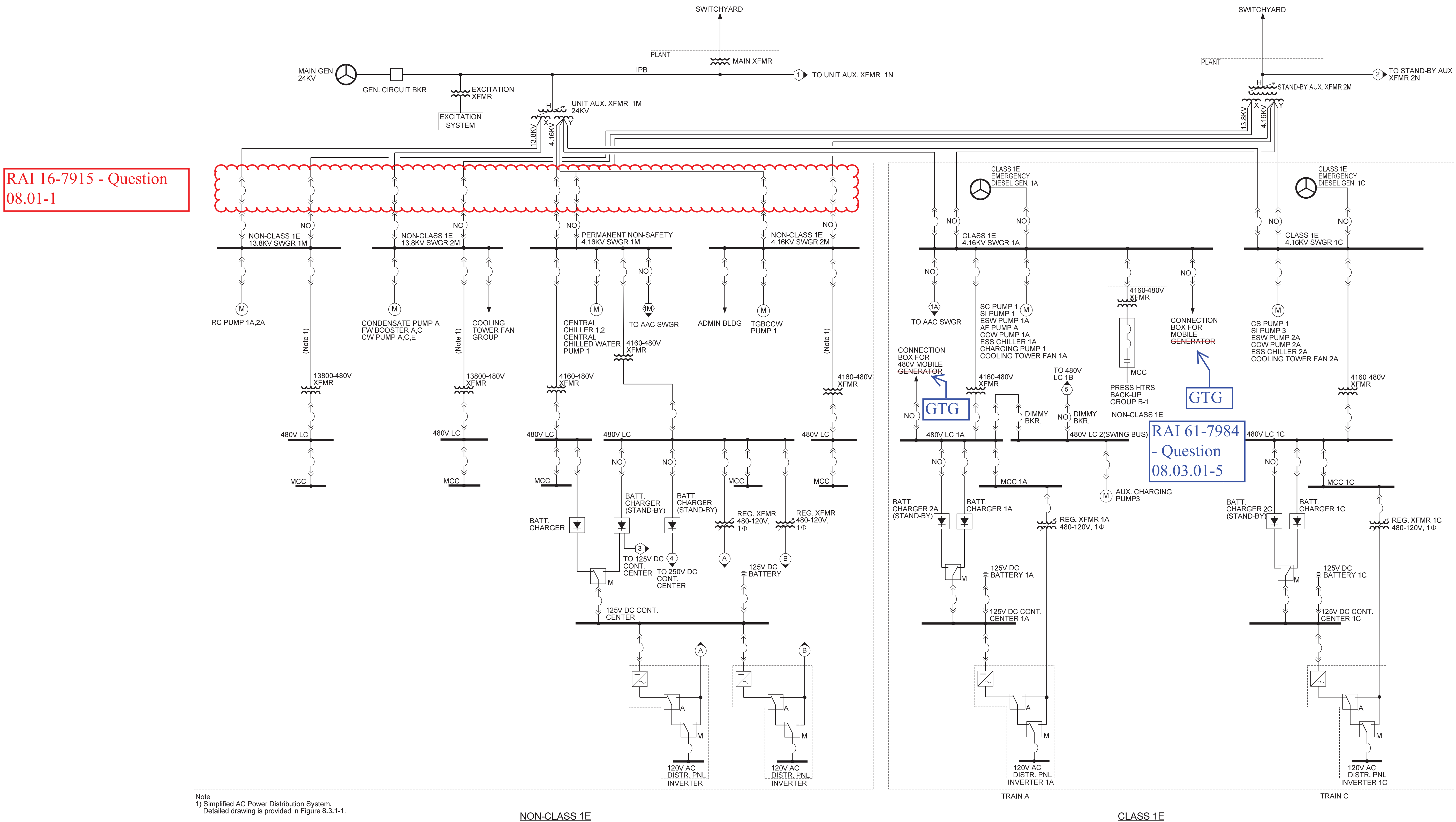


Figure 8.1-1 Electric Power System Single Line Diagram (Division I) (1 of 2)

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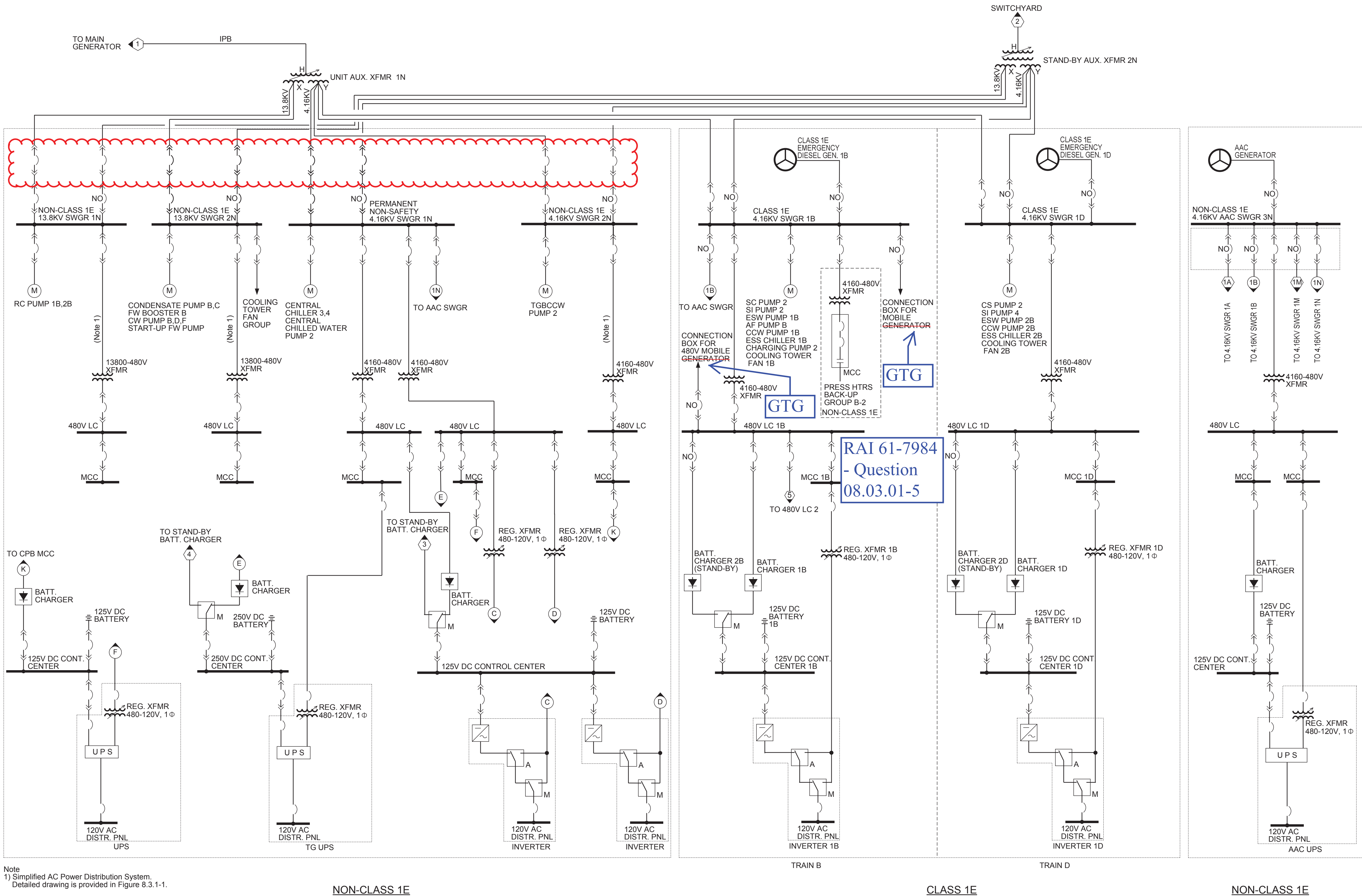


Figure 8.1-1 Electric Power System Single Line Diagram (Division II) (2 of 2)

8.3 Onsite Power Systems

8.3.1 AC Power Systems

8.3.1.1 Description

The onsite ac power system includes standby power sources, distribution systems, and auxiliary supporting systems that are provided to supply power to safety-related equipment or equipment important to safety for all normal operating and accident conditions. There are four Class 1E emergency diesel generators (EDGs) and one non-Class 1E gas turbine generator (GTG). The alternate alternating current (AAC) source is used as a standby power source for the onsite ac power system. The four Class 1E EDGs provide backup power to the Class 1E 4.16 kV buses in the event of a loss of offsite power (LOOP). One Class 1E EDG is dedicated to the respective Class 1E 4.16 kV bus. The non-Class 1E AAC GTG provides backup power to the permanent non-safety (PNS) buses during a LOOP and the dedicated Class 1E 4.16 kV bus during a station blackout (SBO).

The Class 1E ac power system is supplied power from one of the two mobile ~~generators~~ GTGs in case of a beyond-design-basis external event. The connection box provided for the connection of a cable between the mobile ~~generator~~ GTG and the 4.16 kV Class 1E bus is watertight. The connection box is installed in the entry and exit of the auxiliary building where the connection boxes are readily accessible to the mobile ~~generator~~ GTG. The COL applicant is to provide and to design a mobile ~~generator~~ GTG and its support equipment (COL 8.3(1)). In addition, Class 1E switchgear rooms are also designed with watertight exterior barriers and doors to prevent the inflow of floodwater.

add: The mitigation strategies for beyond-design-basis external events, which involve operation of the mobile generators, are described in Section 19.3 of Chapter 19.

The onsite power system consists of the Class 1E power system and the non-Class 1E power system. The onsite power system is normally powered from two unit auxiliary transformers (UATs). In case the power is unavailable from the UATs, the power source for the connected onsite power system Class 1E and non-Class 1E buses is automatically transferred to the standby auxiliary transformers (SATs).

The onsite ac power system consists of the 13.8 kV and 4.16 kV switchgears, 480V load centers, and 480V motor control centers (MCCs). The configuration of the onsite ac power system and offsite power system is shown in Figure 8.1-1.

The ground detector has an alarm in the MCR to monitor constant grounding and recording. The ground detector has high sensitivity.

8.3.3 Combined License Information

GTG

COL 8.3(1) The COL applicant is to provide and to design a mobile ~~generator~~ and its support equipment.

COL 8.3(2) The COL applicant is to describe and provide detailed ground grid and lightning protection.

COL 8.3(3) The COL applicant is to provide testing, inspection, and monitoring programs for detecting insulation degradation of underground and inaccessible power cables within the scope of 10 CFR 50.65.

COL 8.3(4) The COL applicant is to provide protective device coordination.

COL 8.3(5) The COL applicant is to provide insulation coordination of surge and lightning protection.

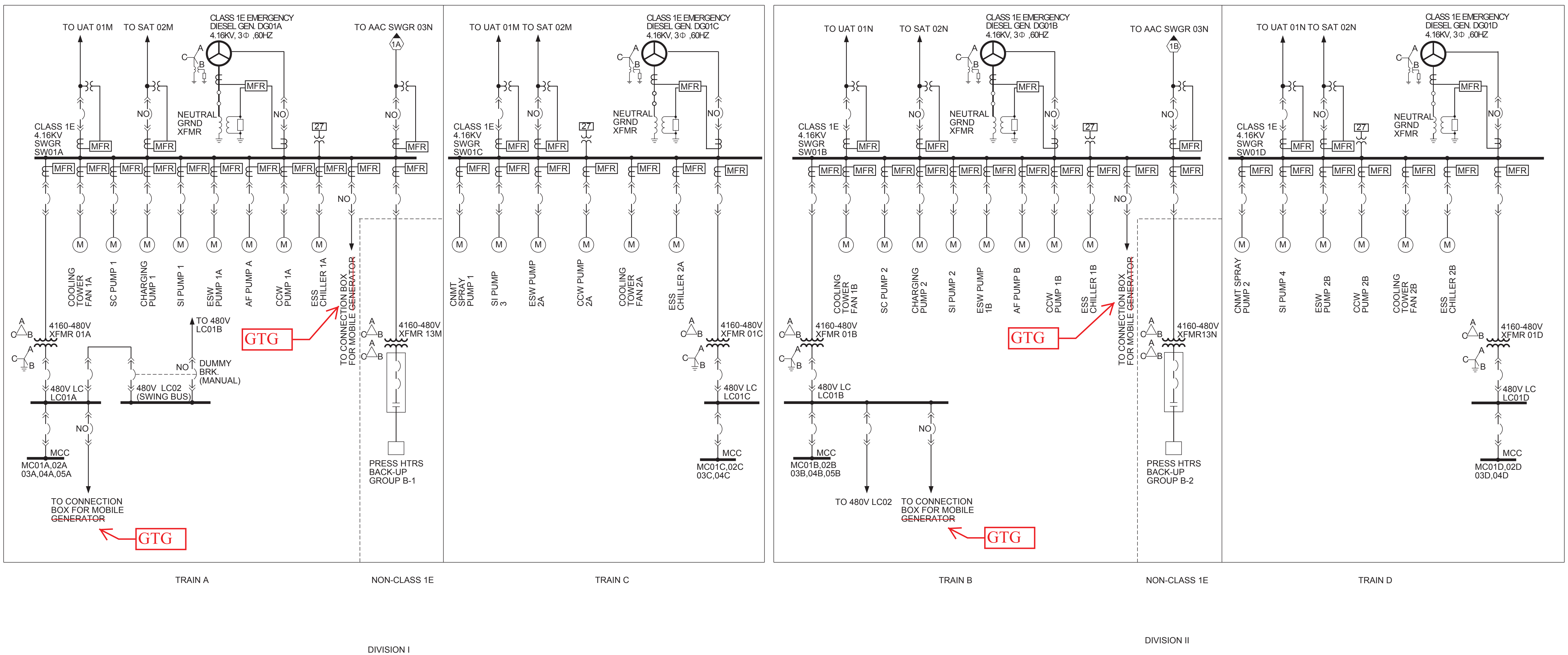
COL 8.3(6) The COL applicant is to develop the maintenance program to optimize the life and performance of the batteries.

COL 8.3(7) The COL applicant is to provide a short-circuit analysis of the onsite dc power system with actual data.

COL 8.3 (8) The COL applicant is to describe any special features of the design that would permit online replacement of an individual cell, group of cells, or entire battery.

8.3.4 References

1. IEEE Std. 141-1993, "IEEE Recommended Practice for Electric Power Distribution for Industrial Plants," Institute of Electrical and Electronics Engineers, 1993.



Class 1E 4.16 kV AC Power System

Figure 8.3.1-1 Onsite AC Electrical Power System (3 of 3)

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Question No. 08.03.01-6

Loss of Voltage and Degraded Voltage Relay Protection:

1. DCD Section 8.3.1.1.3.12, Protective Relaying System, states that “Class 1E buses are provided with separate bus voltage monitoring and protection schemes for degraded and loss of voltage conditions.” Also this section states that “There are four first-level undervoltage (UV) relays to detect loss of voltage, and four second-level UV relays to detect degraded voltage on each of the four Class 1E buses.”

   In describing the schemes, the applicant further states that the dropout for the second-level UV relays for the Class 1E distribution system is set at a level above the minimum voltage that allows proper operation of safety loads with the worst-case line-up and minimum switchyard voltage.

   a. Explain what constitutes the safety loads with worst-case line-up, and how the minimum switchyard voltage is determined. Also, clarify whether the statement “the minimum voltage that allows proper operation of safety loads” means providing the minimum required voltages for important to safety loads for starting and running large motors or the limiting load that is required to meet its intended function during design basis events and accidents.

   b. Provide sufficient basis for staff to understand the proposed scheme, and explain the analytical limit for voltage and time delay chosen for the degraded voltage relay protection (DVR) scheme and the bases as per BTP 8-6 Position 1a, which states that “The selection of UV and time delay setpoints should be determined from an analysis of the voltage requirements of the Class 1E loads at all onsite system distribution level.”

   c. In Regulatory Issue Summary RIS-2011-12, Rev 1, the staff provided a position regarding degraded voltage protection for nuclear power plants after the events at

Millstone and Arkansas. For DVR Setting Design Calculations, this RIS states that voltage calculations should provide the basis for their DVR settings, ensuring safety-related equipment is supplied with adequate voltage, based on bounding conditions for the most limiting safety-related load in the plant. Provide a basis of the voltage studies, ensuring that no improper voltage protection logic can cause adverse effects on the Class 1E systems and equipment due to degraded voltage conditions.

2. Provide a detailed discussion of the loss of voltage protection (LOV) scheme including the analytical limit for voltage and time delay as well as their basis.

3. DCD Section 8.3.1.1.3.12 states that "These relays [LOV and DVR] consists of a two-out-of-four coincidence logic in the component control system (CCS)". Explain the function of the CCS and describe what is meant by two-out-of-four coincidence logic. Discuss how the EDG Actuation functions for Degraded Grid Voltage, Loss of Voltage, and Safety Injection System (SIS) Actuation are implemented in the CCS.

Response

The following are KHNP's responses to each item of the staff's requests:

1.a. Minimum voltage, worst-case line-up, and minimum switchyard voltage

"The minimum voltage that allows proper operation of safety loads" means the minimum voltage at the Class 1E switchgear that allows all of the Class 1E equipment to receive voltages greater than minimum voltage required for equipment operation at the equipment terminals to achieve their safety function during anticipated operational occurrences and design basis accidents. Typically, 0.9 pu of equipment rated voltage is considered as the minimum equipment voltage at which the equipment will perform their required function without damage or adverse effect.

"Worst-case line-up loading condition" is typically determined by considering the maximum unit steady-state and transient loads for events, such as a unit trip, loss-of-coolant accident (LOCA), startup, or shutdown, with the minimum grid voltage. In the APR1400 design, the worst-case line-up is composed of normal operation loads plus LOCA loads with the minimum grid voltage which results in the minimum operating voltage to the onsite power distribution system.

"The minimum switchyard voltage" is determined based on the connected grid voltage variation which is normally between 0.95 and 1.05 pu of grid nominal voltage. The minimum grid voltage, 0.95 pu, is guaranteed by the automatic on-load-tap-changer of the station auxiliary transformers even in the event of grid voltage dips during a grid abnormal condition. Therefore, 0.95 pu of grid nominal voltage is considered the minimum switchyard voltage and used for the onsite power system analysis.

This value is based on experience data from the reference plant and it depends on characteristics of the grid. As described in COL 8.2(3), the COL applicant is to provide the voltage variation of the connecting grid.

1.b. Degraded voltage relay scheme and analytical limit for voltage and time delay

Each Class 1E switchgear has independent detection schemes for the first-level undervoltage relay (hereinafter “loss of voltage relay (LVR)”) and second-level undervoltage relay (hereinafter “degraded voltage relay (DVR)”).

To prevent the Class 1E switchgears from a spurious trip of the preferred power supply (PPS), four LVRs and four DVRs are provided in each Class 1E switchgear with a two-out-of-four coincidence logic. When the voltage setpoint and time delay limit of the relays are exceeded, each LVR or DVR sends an individual detection signal to the component control system (CCS). Upon receipt of at least two individual detection signals out of four from LVRs or DVRs, the CCS gives a trip signal to the incoming circuit breaker of the Class 1E switchgear and an emergency diesel generator (EDG) loading sequencer initiation signal to the CCS group controller.

The two-out-of-four coincidence logic precludes nuisance tripping of the Class 1E switchgear due to any erroneous operation of any single LVR or DVR and also provides reasonable assurance of secure operation of the EDG actuation and loading when a loss of offsite power (LOOP) or a degraded voltage condition occurs with a single failure of any LVR or DVR.

The voltage setpoint of the DVR is established after a voltage analysis on all electrical distribution systems has been performed. The minimum voltage for the DVR is determined in accordance with the following procedure:

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1.c. Voltage studies and protection logic preventing adverse effects on Class 1E systems and equipment

The chance of improper voltage protection logic causing adverse effects on the Class 1E systems and equipment is properly addressed by:

- Voltage setpoint of the DVR is established based on the minimum voltage analysis under the worst-case loading condition
- Tolerance of protective device is considered in the setpoint.
- Time delay of the relays allows for a momentary voltage dip during transient conditions such that nuisance tripping does not occur.
- Each Class 1E SWGR has four DVRs and it is separated from the PPS upon receipt of at least two trip signals from the LVRs or DVRs. This arrangement prevents spurious tripping of a Class 1E SWGR incoming circuit breaker caused by a DVR malfunction.

The selection of the voltage setpoint and time delay for the DVR and the two-out-of-four coincidence logic are discussed in the response to Item 1.b.

2. Loss of voltage relay scheme and analytical limit for voltage and time delay

The LVR is provided to detect the loss of voltage and disconnect the Class 1E switchgear from the PPS in the event of a loss of voltage. The loss of voltage scheme is discussed in the response to Item 1.b.

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3. CCS functions and two-out-of-four coincidence logic

The CCS consists of the ESF-CCS and process-CCS (P-CCS) assemblies and provides control for the different divisions of safety equipment and non-safety equipment. The CCS, described in DCD Tier 2, Subsection 8.3.1.1.3.12, refers to the ESF-CCS that generates the component control signals that are required to actuate the engineered safety features (ESF) functions and associated components. The ESF-CCS also provides the EDG loading sequencer logic.

The two-out-of-four coincidence logic scheme of the LVR and DVR is discussed in the response to Item 1.b.

When LVRs or DVRs detect a loss of voltage or degraded voltage, each LVR or DVR sends an individual detection signal to the ESF-CCS loop controller (LC) which performs a two-out-of-four coincidence logic to initiate the EDG loading sequencer logic correctly. The two-out-of-four coincidence logic transmits an EDG loading sequencer initiation signal to the ESF-CCS group controller (GC) by a hardwired connection. Upon occurrence of a loss of voltage or degraded voltage condition at the Class 1E switchgear, the ESF-CCS GC initiates an automatic start of the associated EDG and sends load shedding signals to the large loads in that power train through the associated ESF-CCS LC. Each EDG is automatically started and runs on receipt of a safety injection actuation signal (SIAS), auxiliary feedwater actuation signal (AFAS), or containment spray actuation signal (CSAS). Further description of the EDG loading sequencer is provided in DCD Tier 2, Subsection 7.3.1.8.

Impact on DCD

There is no impact on the DCD.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.