DESIGN CONTROL DOCUMENT FOR THE

US-APWR

Chapter 8
Electric Power

MUAP- DC008

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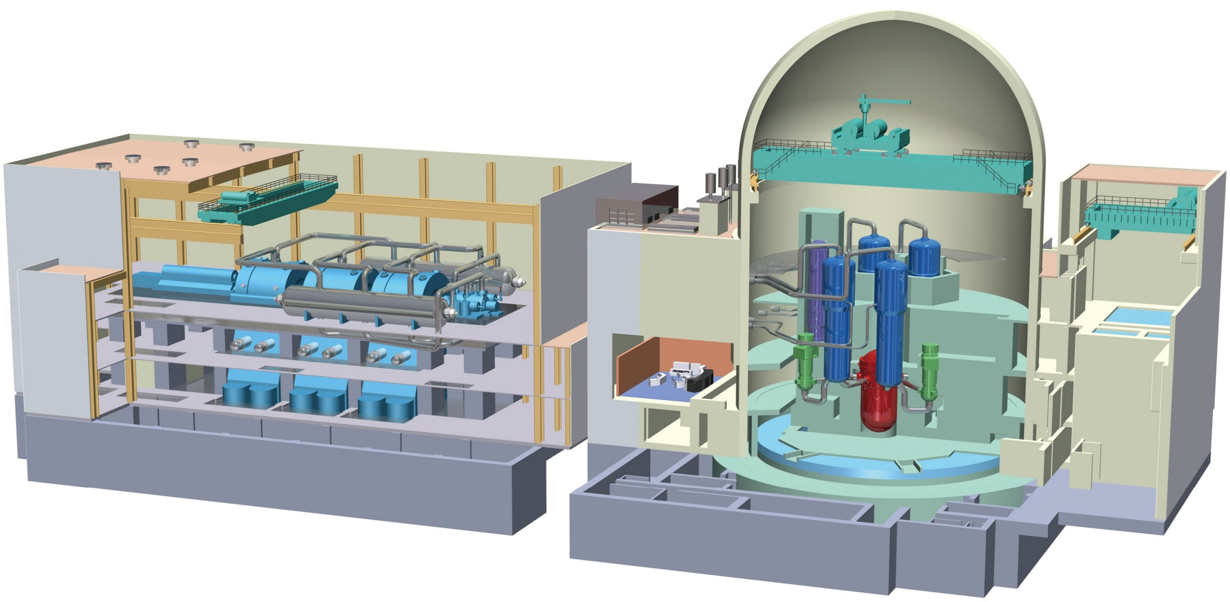

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TABLES

FIGURES

ACRONYMS AND ABBREVIATIONS

ac	alternating current
AAC	alternate alternating current
A/B	auxiliary building
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
BAT	boric acid tank
BTP	branch technical position
CDI	conceptual design information
CFR	Code of Federal Regulations
COL	Combined License
CRDM	control rod drive mechanism
C/V	containment vessel
DBE	design-basis event
dc	direct current
DCD	Design Control Document
ECCS	emergency core cooling system
EFW	emergency feedwater
ETAP	Electrical Transient Analyzer Program
FMEA	failure modes and effects analysis
GDC	General Design Criteria
GLBS	generator load break switch
GTG	gas turbine generator
HVAC	heating, ventilation, and air conditioning
I&C	instrumentation and control
ICEA	Insulated Cable Engineers Association
IEEE	Institute of Electrical and Electronics Engineers
IPB	isolated phase busduct
LOCA	loss-of-coolant accident
LOOP	loss of offsite power
MCC	motor control center
MCCB	molded case circuit breaker
MCR	main control room
MG	main generator
MOV	motor operated valve
MT	main transformer
MV	medium voltage

ACRONYMS AND ABBREVIATIONS (CONTINUED)

NEMA	National Electrical Manufacturer Association
NFPA	National Fire Protection Association
NPGS	nuclear power generating stations
NRC	U.S. Nuclear Regulatory Commission
NUREG	NRC Technical Report Designation (Nuclear Regulatory Commission)
OLTC	on-load tap changer
PA	postulated accident
PPS	preferred power supply
PS/B	power source building
RAT	reserve auxiliary transformer
RCP	reactor coolant pump
RCS	reactor coolant system
RG	Regulatory Guide
RTD	resistance temperature detectors
R/B	reactor building
SBO	station blackout
SDV	safety depressurization valve
SRP	Standard Review Plan
SSC	structure, system, and component
SST	station service transformer
T/B	turbine building
T/D	turbine driven
UAT	unit auxiliary transformer
UPS	uninterruptible power supply
US	United States

8.0 ELECTRIC POWER

8.1 Introduction

8.1.1 General

Offsite electric power is provided to the US-APWR plant site from the grid by at least two physically independent transmission lines. During the plant startup and shutdown and during all postulated accident conditions, the offsite electric power is supplied to the plant site from the plant high voltage switchyard through two physically independent transmission tie lines. One of these two transmission tie lines connects to the high voltage side of the main transformer (MT), and the other connects to the high voltage side of the reserve auxiliary transformers (RATs). The main generator (MG) is connected to the low voltage side of the MT and the high voltage side of the unit auxiliary transformers (UATs). There is a generator load break switch (GLBS) between the MG and the MT. When the MG is on-line, it provides power to the onsite non safety-related electric power system through the UATs. When the GLBS is open, offsite power to the onsite non safety-related electric power system is provided through the MT and the UATs. With the GLBS either open or closed, offsite power to the onsite safety-related electric power system is provided through the RATs. If power is not available through the UATs, offsite power is provided to both safety-related and non safety-related onsite electric power system through the RATs. Similarly, if power is not available through the RATs, offsite power is provided to both safety-related and non safety-related onsite electric power system through the UATs.

The onsite electric power system provides power to all plant auxiliary and service loads. The onsite electric power system is comprised of alternating current (ac) and direct current (dc) systems. Both ac and dc onsite electric power systems have a safety-related Class 1E power system feeding all Class 1E loads, and a non safety-related non-Class 1E power system feeding all non-Class 1E loads. The Class 1E onsite power system has four independent trains. Each train of the Class 1E ac onsite power system, in addition to their connection to offsite power sources from the grid, has an onsite emergency power source, consisting of a generator driven by a gas turbine. Each train of the Class 1E dc onsite power distribution system, in addition to their connection to corresponding ac train through a battery charger, is provided with a dedicated Class 1E battery power source.

The reference plant has two circuits connected to offsite power sources, four onsite Class 1E emergency gas turbine generator (GTG) power sources, two onsite non-Class 1E GTG power sources and, four Class 1E and four non-Class 1E dc battery power sources. The non-Class 1E GTGs provide power to all electrical loads that are required to bring the unit into, and maintain the unit in, a safe-shutdown mode upon the loss of all offsite and onsite ac power sources.

Figure 8.1-1 is a simplified electrical one line diagram depicting the ac and dc onsite and offsite electric power system for the reference plant. The one line diagram containing site-specific information, described in Section 8.2, is to be provided by the Combined License (COL) applicant.

8.1.2 Utility Power Grid and Offsite Power System Description

8.1.2.1 Utility Power Grid Description

The plant operating company's grid system and its interconnections to other grid systems and generating stations are site-specific and not within the scope of the reference plant design. Those items are discussed in Section 8.2.

8.1.2.2 Offsite Power System Description

Offsite power sources are the preferred sources of power for the safety-related Class 1E onsite electric power system. The normal preferred source is grid power through the RATs to the safety-related Class 1E 6.9 kV buses. The alternate preferred source is the grid power backfed through the MT and through the UATs to the safety-related Class 1E 6.9 kV buses.

The circuit breakers at the switchyard, the transmission tie lines between the switchyard and the plant, the MT, isolated phase busduct (IPB), GLBS, UATs, RATs, and their connections to the 13.8 kV and 6.9 kV buses, are the major components of the offsite electric power system. The offsite power system begins at the terminals on the transmission line side of the circuit breakers at the switchyard connecting to the transmission systems. It ends at the line side terminals of the main power supply circuit breakers feeding the 13.8 kV and 6.9 kV buses, and at the terminals on the MT side of the GLBS.

During the plant startup, normal and emergency shutdown, including all postulated accident conditions, the offsite power system brings power from the offsite transmission system to the onsite electric power system. During normal plant operation, the offsite power system is used to transmit generated power to the offsite transmission systems and to provide power to plant auxiliary and service loads through the onsite electric power system.

The components of the offsite power system that are associated with the normal preferred power supply (PPS), and the components that are associated with the alternate preferred power supply are physically separated and designed to exclude, to the extent practical, the potential for simultaneous failure of the normal and alternate preferred power supply systems under operating, and postulated accident conditions.

8.1.3 Onsite Power System Description

The onsite power system consists of an ac power system and a dc power system. Both systems are comprised of Class 1E and non-Class 1E subsystems. All plant auxiliary and service loads are supplied power from the onsite power system. Two independent power circuits of the offsite power system can supply power to the onsite power system. Four Class 1E GTGs provide backup power to the ac Class 1E onsite power system. The reference plant also has two non-Class 1E GTGs as alternate alternating current (AAC) power source. Both Class 1E and non-Class 1E dc systems are normally powered by the battery chargers connected to the onsite ac power system. When power supply from the battery charger is not available, the onsite dc power system is supplied power from station batteries.

There are two non-Class 1E 13.8 kV medium voltage (MV) buses N1 and N2, four non-Class 1E 6.9 kV MV buses N3, N4, N5 and N6, two non-Class 1E 6.9 kV MV permanent buses P1 and P2, and four Class 1E 6.9 kV MV buses A, B, C and D. All low voltage buses are provided power from the MV buses. Each of the Class 1E 6.9 kV MV buses has its own onsite Class 1E standby emergency power source. Similarly, each of the non-Class 1E 6.9 kV MV permanent buses has its own onsite non-Class 1E standby emergency power source, designated as AAC power source. All MV buses can be powered from either UAT or RAT.

There are four, two-winding, UATs, namely UAT1, UAT2, UAT3, and UAT4. The high side of these transformers is connected to the main generator isolated phase bus down-stream of the GLBS. During normal power operation of the plant with the GLBS closed, the MG provides power to the plant MV buses N1, N2, N3, N4, N5 and N6, and MV permanent buses P1 and P2 through the UATs. During all other modes of plant operation, including postulated accident (PA), with the GLBS open, these MV buses are powered through the UATs by back-feeding the MT from the offsite power sources. During all modes of plant operation including startup, normal and emergency shutdown and PA, the MV Class 1E buses A, B, C and D are powered through the RATs from offsite power sources.

There are four, three-winding RATs, namely RAT1, RAT2, RAT3, and RAT4. The high side of these transformers is connected to the high voltage transmission tie line from the switchyard. The transmission tie line voltage level is site-specific. This is the normal preferred power source for all plant safety-related auxiliary and service loads. RAT1 and RAT2 can feed the 13.8 kV non-Class 1E buses N1 and N2, respectively. RAT3 can feed the Class 1E 6.9 kV buses A and B, and non-Class 1E buses N3, N4 and P1. RAT4 can feed the Class 1E 6.9 kV buses C and D, and non-Class 1E buses N5, N6 and P2.

Each of the safety-related and non safety-related MV buses (non-Class 1E 13.8 kV buses N1 and N2; Class 1E 6.9 kV buses A, B, C, and D; and non-Class 1E 6.9 kV buses N3, N4, N5, N6, P1 and P2) is connected to both an UAT and a RAT. For all Class 1E (A, B, C and D) MV buses, power from the RAT is the normal preferred source and power from the UAT is the alternate preferred source. Each safety-related MV bus also has its own backup emergency power supply from a safety-related Class 1E GTG. MV permanent buses P1 and P2 also have their own backup emergency power supply from a dedicated non-Class 1E GTG.

In addition to the 13.8 kV and 6.9 kV MV levels, the onsite power distribution system has also other low voltage (480 V ac, 208/120 V ac, 125 V dc, etc.) power distribution systems. The MV buses feed the 480V load center buses through the station service transformers (SSTs). The 480V load center buses feed the 480V motor control center (MCC) buses except the 480V ac motor operated valve (MOV) MCCs, which are supplied from the inverters. The 480V MCC buses feed the 208/120 V buses through distribution transformers. The 480V MCC buses also feed the 125 V dc buses through battery chargers. The safety-related MV buses A, B, C and D feed the corresponding safety-related low voltage buses, and the non safety-related MV buses feed the non safety-related low voltage buses.

The onsite power distribution system also includes both safety and non-safety instrumentation and control (I&C) power supply systems. The I&C power supply systems are 120 V ac uninterruptible power supply (UPS) systems used for the reference plant's instrumentation and control systems. The UPS systems are normally powered from the 480V MCCs through inverters with battery backup.

8.1.3.1 Safety Systems

The Class 1E ac onsite power system configuration is shown in Figure 8.3.1-1. The Class 1E 120 V ac I&C power supply system configuration is shown in Figure 8.3.1-3. The Class 1E dc power distribution system configuration is shown in Figure 8.3.2-1.

Both Class 1E ac and dc onsite power systems consist of four completely independent power supply systems, identified as A, B, C, and D train. In general, the plant safety-related loads are also divided into A, B, C, and D redundant load groups (four 50% systems). Each load group is served by a corresponding train of the power supply system. The safety systems that have four load groups require any two out of the four load groups to be operable for the applicable safety function. There are some safety-related ac and dc loads that are divided into two redundant load groups (two 100% systems). The safety systems that have two load groups require one out of the two load groups to be operable for the applicable safety function. These two 100% ac load groups are served by Class 1E 480V load center buses A1 and D1. The A1 load center bus is normally connected to the train A Class 1E 480V load center. During a maintenance outage of train A GTG, the A1 load center is manually connected to the train B Class 1E 480V load center. Similarly, the D1 load center bus is normally connected to the train D Class 1E 480V load center. During a maintenance outage of train D GTG, the D1 load center is manually connected to the train C Class 1E 480V load center. The two 100% dc load groups are served basically by Class 1E 125V dc buses A1 and D1. The A1 dc bus is normally connected to the train A Class 1E 125V dc bus. During a maintenance outage of train A GTG, the A1 dc bus is manually connected to the train B Class 1E 125V dc bus. The D1 bus connection is similar to A1 bus. Each I&C power system train has a similar 120V ac panelboard, which can be supplied power from its own train and from another train. The power supply to the panelboards is realigned to the UPS of another train during a maintenance outage of the GTG of its own train. An example methodology of how physical independence and redundancy are maintained during GTG maintenance outages is included in the RG 1.75 conformance discussion of Subsection 8.3.1.2.2. The onsite ac and dc distribution configuration provides for safe shutdown of the plant with any two safety-related power supply trains assuming a single failure coincident with online maintenance of a Class 1E GTG in any other train.

8.1.3.2 Non Safety Systems

The ac non safety-related power distribution system configuration is shown in Figure 8.3.1-1. The non safety ac I&C power supply system configuration is shown in Figure 8.3.1-3. The non safety dc power distribution system configuration is shown in Figure 8.3.2-1.

The majority of the plant non safety auxiliary and service loads are divided into two or more load groups for improved plant performance and reliability. Accordingly, the non safety-related ac, dc and the I&C power supply systems are also divided into two or more redundant groups. However, there is no specific physical separation or electrical isolation requirements between these redundant groups. Non safety-related power distribution system buses are designated with prefix “N” or “P.” The P buses can be powered from the alternate ac power sources. The N and P power distribution systems are electrically isolated and physically separated from all trains of the Class 1E safety-related power distribution system.

8.1.4 Safety-Related Loads

Safety-related loads are defined as those systems and components that require electric power in order to perform their safety functions. The safety-related loads are supplied power from the safety-related Class 1E power distributions systems. The ac safety-related loads are listed in Table 8.3.1-4, Table 8.3.1-7 and Table 8.3.1-10. The dc safety-related loads are listed in Table 8.3.2-1.

8.1.5 Design Bases

8.1.5.1 Offsite Power System

The transmission grid and its interconnections to other generating stations and other grid systems, the plant high voltage switchyard and the transmission tie lines (minimum two) between the plant high voltage switchyard and the transformer yard are discussed in Section 8.2. The following are the design bases that are applicable to offsite power system, irrespective of whether they are part the reference plant design.

All plant loads are supplied offsite power from four UATs or four RATs.

At a minimum, there are two physically independent power circuits between the offsite grid and the plant high voltage switchyard, and between the plant high voltage switchyard and the plant onsite power system. The two power circuits are designed and located to minimize, to the extent practical, the likelihood of their simultaneous failure under operating conditions and postulated accident conditions. Each power circuit has sufficient capacity and capability to assure satisfactory operation of all safety and non safety-related loads.

Upon unit trip for any reason, including a postulated accident, (except due to electrical fault in the power supply circuit affecting the UATs), the GLBS is opened and the plant’s non-Class 1E MV buses N1 through N6, P1 and P2 continue to receive power from offsite sources through the UATs. In case of a unit trip due to an electrical fault in the power supply circuit affecting the UATs, the high voltage circuit breaker at the switchyard connected to the MT, and all UAT incoming circuit breakers at the MV switchgear buses N1 through N6, P1 and P2 are opened. MV switchgear buses N1 through N6, P1 and P2 are transferred from the UATs to the RATs. During all modes of plant operation, including startup, normal and emergency shutdown and postulated accident conditions, the Class 1E MV buses A, B, C and D are fed from the normal preferred offsite power source through the RATs. These buses are transferred to the alternate preferred power source through the UATs upon loss of normal preferred power source from the RATs.

8.1.5.2 Onsite Power System

The design bases for the onsite power system are as follows:

1. The safety-related onsite power system includes four independent and redundant Class 1E electric power systems.

2. The onsite Class 1E electric power systems comprise four independent and redundant trains, each with its own power supply, buses, transformers, and associated controls.

3. One independent Class 1E GTG is provided for each Class 1E train.

   The GTG provides power to the ventilation equipment that maintains an acceptable environment within the GTG room.

   The GTG is capable of starting, accelerating, being loaded, and carrying the design load described in Subsection 8.3.1.

   Mechanical and electrical supporting systems are designed so that a single failure can only affect the operation of one GTG.

   Design conditions such as vibration, torsional vibration, and over-speed are established in accordance with the requirements of the Institute of Electrical and Electronics Engineers (IEEE) Standard 387 (Reference 8.1-1) as they can be applied to a GTG and Regulatory Guide (RG) 1.9 (Reference 8.1-2).

4. There is no automatic load transfer between redundant trains.

5. Non safety-related ac and dc power systems are provided for the non safety-related loads and controls, completely independent from the Class 1E power systems. The non safety-related ac and dc power systems are non-Class 1E.

6. Raceways are not shared by Class 1E and non-Class 1E cables.

7. Special identification criteria are applied for Class 1E equipment, including cables and raceways.

8. Separation criteria, which establish requirements for preserving the independence of redundant Class 1E electric systems, are applied among any redundant Class 1E systems and between any Class 1E system and non-Class 1E systems

9. Class 1E equipment is designed with the capability of being tested periodically.

8.1.5.3 Design Criteria, Regulatory Guides, and Institute of Electrical and Electronics Engineers Standards

Compliance to General Design Criteria (GDC) 17 and 18 (Reference 8.1-3) is discussed in Section 3.1 and in Subsections 8.3.1.2 and 8.3.2.2. The design of the offsite power and the Class 1E electric systems conforms to RGs and industry standards listed below, as clarified in Section 1.9. Refer to Table 8.1-1 for the design criteria and guidelines applicable to Chapter 8.

8.1.5.3.1 General Design Criteria

See Section 3.1 for a discussion of conformance with each of the GDC.

Title 10, Code of Federal Regulations (CFR) Part 50 Appendix A:

- GDC 2, Design Bases for Protection Against Natural Phenomena
- GDC 4, Environmental and Dynamic Effects Design Bases
- GDC 5, Sharing of Structures, Systems, and Components
- GDC 17, Electric Power Systems
- GDC 18, Inspection and Testing of Electric Power Systems
- GDCs 33, 34, 35, 38, 41 and 44
- GDC 50, Containment Design Basis

8.1.5.3.2 Nuclear Regulatory Commission Regulatory Guides

See Section 1.9 for a discussion of conformance to the following RGs:

- Regulatory Guide 1.206, “Combined License Applications for Nuclear Power Plants” (LWR Edition), June 2007
- Regulatory Guide 1.6, “Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems,” (Safety Guide 6), Rev. 0, March 1971
- Regulatory Guide 1.9, “Application and Testing for Safety-Related Diesel Generators in Nuclear Power Plants,” Rev. 4, March 2007
- Regulatory Guide 1.22, “Periodic Testing of Protection System Actuation Functions,” (Safety Guide 22), Rev. 0, February 1972
- Regulatory Guide 1.29, “Seismic Design classification,” Rev. 4, March 2007
- Regulatory Guide 1.30, “Quality Assurance Requirements for the Installation, Inspection and Testing of Instrumentation and Electric Equipment (Safety Guide 30), August 1972
- Regulatory Guide 1.32, “Criteria for Power Systems for Nuclear Power Plants” Rev. 3, March 2004

- Regulatory Guide 1.40, “Qualification of Continuous Duty Safety-Related Motors for Nuclear Power Plants,” Rev. 1, February 2010
- Regulatory Guide 1.41, “Preoperational Testing of Redundant On-site Electric Power Systems to Verify Proper Load Group Assignments,” Rev. 0, March 1973
- Regulatory Guide 1.47, “Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems,” Rev. 0, May 1973
- Regulatory Guide 1.53, “Application of the Single-Failure Criterion to Safety Systems,” Rev. 2, November 2003
- Regulatory Guide 1.62, “Manual Initiation of Protective Actions,” Rev. 0, October 1973
- Regulatory Guide 1.63, “Electric Penetration Assemblies in Containment Structures for Nuclear Power Plants,” Rev. 3, February 1987
- Regulatory Guide 1.73, “Qualification Tests of Electric Valve Operators Installed Inside the Containment of Nuclear Power Plants,” Rev. 0, January 1974
- Regulatory Guide 1.75, “Criteria for Independence of Electrical Safety Systems,” Rev. 3, February 2005
- Regulatory Guide 1.81, “Shared Emergency and Shutdown Electric Systems for Multi-Unit Nuclear Power Plants,” Rev. 1, January 1975
- Regulatory Guide 1.89, “Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants,” Rev. 1, June 1984
- Regulatory Guide 1.93 (DG-1153), “Availability of Electric Power Sources,” Rev. 0, December 1974
- Regulatory Guide 1.100, “Seismic Qualification of Electric and Mechanical Equipment for Nuclear Power Plants,” Rev. 2, June 1988
- Regulatory Guide 1.106, “Thermal Overload Protection for Electric Motors on Motor-Operated Valves,” Rev. 1, March 1977
- Regulatory Guide 1.118, “Periodic Testing of Electric Power and Protection Systems,” Rev. 3, April 1995
- Regulatory Guide 1.128, “Installation Design and Installation of Vented Lead-Acid Storage Batteries for Nuclear Power Plants,” Rev. 2, February 2007
- Regulatory Guide 1.129 , “Maintenance, Testing, and Replacement of Vented Lead-Acid Storage Batteries for Nuclear Power Plants,” Rev. 2, February 2007

- Regulatory Guide 1.137, “Fuel-Oil Systems for Standby Diesel Generators,” Rev. 1, October 1979
- Regulatory Guide 1.153, “Criteria for Safety Systems,” Rev. 1, June 1996
- Regulatory Guide 1.155, “Station Blackout,” Rev. 0, August 1988
- Regulatory Guide 1.156, “Environmental Qualification of connection Assemblies for Nuclear Power Plants,” Rev. 0, November 1987
- Regulatory Guide 1.158, “Qualification of Safety-Related Lead Storage Batteries for Nuclear Power Plants,” Rev. 0, February 1989
- Regulatory Guide 1.160, “Monitoring the Effectiveness of Maintenance at Nuclear Power Plants,” Rev. 2, March 1997
- Regulatory Guide 1.180, “Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems,” Rev. 1, October 2003
- Regulatory Guide 1.182, “Assessing and Managing Risk Before Maintenance Activities at Nuclear Power Plants,” Rev. 0, May 2000
- Regulatory Guide 1.189, “Fire Protection for Nuclear Power Plants,” Rev. 1, March 2007
- Regulatory Guide 1.204, “Guidelines for Lightning Protection of Nuclear Power Plants,” Rev. 0, November 2005
- Regulatory Guide 1.211, “Qualification of Safety-Related Cables and Field Splices for Nuclear Power Plants,” Rev. 0, April 2009
- Draft Regulatory Guide DG-1153, “Availability of Electric Power Sources,” October 2006

8.1.5.3.3 Nuclear Regulatory Commission Branch Technical Positions

The offsite and onsite electric power systems design conforms to the criteria, guidelines and recommendations provided in the following branch technical positions (BTPs):

- BTP 8-1, “Requirements for Motor-Operated Valves in the ECCS Accumulator Lines.”
- BTP 8-2, “Use of Diesel Generator Sets for Peaking.” The requirements of this BTP that are pertinent to a GTG are implemented in the US-APWR design.
- BTP 8-3, “Stability of Offsite Power Systems.”

- BTP 8-4, “Application of Single Failure Criterion to Manually Controlled Electrically Operated Valves.”
- BTP 8-5, “Supplemental Guidance for Bypass and Inoperable Status Indication for Engineered Safety Features Systems.”
- BTP 8-6, “Adequacy of Station Electric Distribution System Voltages.”
- BTP 8-7, “Criteria for Alarms and Indications Associated with Diesel Generator Unit Bypassed and Inoperable Status.” The requirements of this BTP that are pertinent to a GTG are implemented in US-APWR design.

8.1.5.3.4 NRC Generic Letters

The offsite and onsite electric power systems design conforms to the criteria, guidelines and recommendations provided in the following U.S. Nuclear Regulatory Commission (NRC) Generic Letters:

- Generic Letter 77-07, “Reliability of Standby Diesel Generator Units.” The requirements of this Generic Letter that are pertinent to a GTG are implemented in US-APWR design.
- Generic Letter 79-17, “Reliability of Onsite Diesel Generators at Light-Water Reactors.” The requirements of this Generic Letter that are pertinent to a GTG are implemented in US-APWR design.
- Generic Letter 84-15, “Proposed Staff Actions to Improve and Maintain Diesel Generator Reliability.” The requirements of this Generic Letter that are pertinent to a GTG are implemented in US-APWR design.
- Generic Letter 88-15, “Electric Power Systems – Inadequate Control Over Design Process.”
- Generic Letter 91-11, “Resolution of Generic Issues 48, ‘LCOs for Class 1E Vital Instrument Buses,’ and 49, ‘Interlocks and LCOs for Class 1E Tie Breakers,’ pursuant to 10 CFR 50.54(f).”
- Generic Letter 94-01, “Removal of Accelerated Testing and Special Reporting Requirements for Emergency Diesel Generators.” The requirements of this Generic Letter that are pertinent to a GTG are implemented in US-APWR design.
- Generic Letter 96-01, “Testing of Safety-Related Logic Circuits.”
- Generic Letter 2006-02, “Grid Reliability and the Impact on Plant Risk and the Operability of Offsite Power.”
- Generic Letter 2007-01, “Inaccessible or Underground Power Cable Failures That Disable Accident Mitigation Systems or Cause Plant Transients”

8.1.5.3.5 Institute of Electrical and Electronics Engineers Standards

The onsite electric power system design conforms to the criteria and recommendations provided in the following IEEE, and other industry standards such as American National Standards Institute (ANSI), National Electrical Manufacturer Association (NEMA), National Fire Protection Association (NFPA) and Insulated Cable Engineers Association (ICEA). The switchyard and transmission system design conforms to the standards discussed in Section 8.2.

- IEEE Std 48-1996, “IEEE Standard Test Procedures and Requirements for Alternating-Current Cable Terminations 2.5 kV through 765 kV”
- IEEE Std 80-2000, “IEEE Guide for Safety in AC Substation Grounding”
- IEEE Std 81-1983, "IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System"
- IEEE Std 141-1993, “IEEE Recommended Practice for Electric Power Distribution for Industrial Plants”
- IEEE Std 142-2007, “IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems”
- IEEE Std 242-2001, “IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems”
- IEEE Std 308-2001, “IEEE Standard Criteria for Class 1E Power Systems for Nuclear Power Generating Stations”
- IEEE Std 317-1983, “IEEE Standard for Electric Penetration Assemblies in Containment Structures for Nuclear Power Generating Stations”
- IEEE Std 323-2003, “IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations”
- IEEE Std 334-1994, “IEEE Standard for Qualifying Continuous Duty Class 1E Motors for Nuclear Power Generating Stations”
- IEEE Std 336-2005, “IEEE Guide for Installation, Inspection, and Testing for Class 1E Power, Instrumentation, and Control Equipment at Nuclear Facilities”
- IEEE Std 338-2006, “IEEE Standard Criteria for the Periodic Surveillance Testing of Nuclear Power Generating Station Safety Systems”
- IEEE Std 344-2004, “IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations”
- IEEE Std 379-2000, “IEEE Standard Application of the Single-Failure Criterion to Nuclear Power Generating Station Safety Systems”

- IEEE Std 382-2006, “IEEE Standard for Qualification of Safety Related Actuators for Nuclear Power Generating Stations”
- IEEE Std 383-2003, “IEEE Standard for Qualifying Class 1E Electric Cables and Field Splices for Nuclear Power Generating Stations”
- IEEE Std 384-1992, “IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits”
- IEEE Std 386-2006, “IEEE Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600 V”
- IEEE Std 387-1995, “IEEE Standard Criteria for Diesel-Generator Units Applied as Standby Power Supplies for Nuclear Power Generating Stations.” Note: The reference plant has GTG as standby power supply and this standard is applicable to diesel-generator. The criteria and recommendations of the standard that are applicable to GTG are implemented in the standby power supply design.
- IEEE Std 399-1997, “IEEE Recommended Practice for Industrial and Commercial Power System Analysis”
- IEEE Std 420-2001, “IEEE Standard for the Design and Qualification of Class 1E Control Boards, Panels and Racks Used in Nuclear Power Generating Stations”
- IEEE Std 422-1986, “Guide for the Design and Installation of Cable Systems in Power Generating Stations”
- IEEE Std 434-2006, “IEEE Guide for Functional Evaluation of Insulation Systems for AC Electric Machine Rated 2300 V and Above”
- IEEE Std 446-1995, “IEEE Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications"
- IEEE Std 450-2002, “IEEE Recommended Practice for Maintenance, Testing and Replacement of Vented Lead-Acid Batteries for Stationary Applications”
- IEEE Std 484-2002, “IEEE Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications”
- IEEE Std 485-1997, “IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications”
- IEEE Std 497-2002, “IEEE Standard Criteria for Accident Monitoring Instrumentation for Nuclear Power Generating Stations”
- IEEE Std 505-1977, “IEEE Standard Nomenclature for Generating Station Electric Power Systems”

- IEEE Std 519-1992, “IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems”
- IEEE Std 524a-1993, "IEEE Guide to Grounding During the Installation of Overhead Transmission Line Conductors"
- IEEE Std 535-2006, “IEEE Standard for Qualification of Class 1E Lead Storage Batteries for Nuclear Power Generating Stations”
- IEEE Std 572-2006, “IEEE Standard for Qualification of Class 1E Connection Assemblies for Nuclear Power Generating Stations”
- IEEE Std 577-2004, “Standard Requirements for Reliability Analysis in the Design and Operation of Safety Systems for Nuclear Facilities”
- IEEE Std 603-1998, “IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations”
- IEEE Std 622-1987, “IEEE Recommended Practice for the Design and Installation of Electric Heat Tracing Systems for Nuclear Power Generating Systems
- IEEE Std 628-2001, “IEEE Standard Criteria for the Design, Installation and Qualification of Raceway Systems for Class 1E Circuits for Nuclear Power Generating Stations”
- IEEE Std 638-1992 (R1999), “Qualification of Class 1E Transformers for Nuclear Power Generating Stations”
- IEEE Std 649-2006, “IEEE Standard for Qualifying Class 1E Motor Control Centers for Nuclear Power Generating Stations”
- IEEE Std 650-2006, “IEEE Standard Qualification of Class 1E Battery Chargers and Inverters for Nuclear Power Generating Stations”
- IEEE Std 665-1995, “IEEE Standard for Generating Station Grounding”
- IEEE Std 666-1991, “IEEE Design Guide for Electric Power Service Systems for Generating Stations”
- IEEE Std 690-2004, “IEEE Standard for the Design and Installation of Cable Systems for Class 1E Circuits in Nuclear Power Generating Stations”
- IEEE Std 692-1997, “IEEE Standard Criteria for Security Systems for Nuclear Power Generating Stations”
- IEEE Std 741-1997, “IEEE Standard Criteria for the Protection of Class 1E Power Systems and Equipment in Nuclear Power Generating Stations”

- IEEE Std 765-2006, “IEEE Standard for Preferred Power Supply (PPS) for Nuclear Power Generating Stations (NPGS)”
- IEEE Std 803-1983, “IEEE Recommended Practice for Unique Identification in Power Plants and Related Facilities – Principles and Definitions”
- IEEE Std 805-1984, “IEEE Recommended Practice for System Identification in Nuclear Power Plants and Related Facilities”
- IEEE Std 833-2005, “IEEE Recommended Practice for the Protection of Electric Equipment in Nuclear Power Generating Stations from Water Hazards”
- IEEE Std 835-1994, “IEEE Standard Power Cable Ampacity Tables”
- IEEE Std 845-1999, “IEEE Guide for the Evaluation of Human-System Performance in Nuclear Power Generating Stations”
- IEEE Std 933-1999, “Guide for the Definition of Reliability Program Plans for Nuclear Power Generating Stations”
- IEEE Std 944-1986, “IEEE Recommended Practice for the Application and Testing of Uninterruptible Power Supplies for Power Generating Stations”
- IEEE Std 946-2004, “IEEE Recommended Practice for the Design of dc Auxiliary Power Systems for Generating Stations”
- IEEE Std 1015-2006, “IEEE Recommended Practice for Applying Low Voltage Circuit Breakers Used in Industrial and Commercial Power Systems”
- IEEE Std 1023-2004, “IEEE Recommended Practice for the Application of Human Factors Engineering to Systems, Equipment and Facilities of Nuclear Power Generating Stations and Other Nuclear Facilities”
- IEEE Std 1050-2004, “IEEE Guide for Instrumentation and Control Equipment Grounding in Generating Stations”
- IEEE Std 1082-1997, “Guide for Incorporating Human Action Reliability Analysis for Nuclear Power Generating Stations”
- IEEE Std 1143-1994, “IEEE Guide on Shielding Practice for Low Voltage Cables”
- IEEE Std 1184-2006, “IEEE Guide for Batteries for Uninterruptible Power Supply Systems”
- IEEE Std 1185-1994, ”IEEE Guide for Installation Methods for Generating Station Cables”
- IEEE Std 1202-2006, “IEEE Standard for Flame-Propagation Testing of Wire and Cable”

- IEEE Std 1205-2000, “IEEE Guide for Assessing, Monitoring, and Mitigating Aging Effects on Class 1E Equipment Used in Nuclear Power Generating Stations” (Corrigendum 1: 2006)
- IEEE Std 1290-1996, “IEEE Guide for Motor Operated Valve (MOV) Motor Application, Protection, Control, and Testing in Nuclear Power Generating Stations”
- IEEE Std 1313.1-1996, "IEEE Standard for Insulation Coordination—Definitions, Principles, and Rules"
- IEEE Std 1313.2-1999, "IEEE Guide for the Application of Insulation Coordination"
- IEEE Std 1349-2001, “IEEE Guide for Application of Electric Motors in Class I, Division 2 Hazardous (Classified) Locations”
- IEEE Std 1375-1998, “IEEE Guide for Protection of Stationary Battery Systems”
- ANSI/IEEE 1584-2002, “Guide for Performing Arc Flash Hazard Calculations”
- IEEE Std 1584a-2004, “IEEE Guide for Performing Arc-Flash Hazard Calculations – Amendment 1”
- IEEE Std C37.010-1999, “IEEE Application Guide for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis”
- IEEE Std C37.011-2005, “IEEE Application Guide for Transient Recovery Voltage for AC High-Voltage Circuit Breakers”
- IEEE Std C37.2-1996, “IEEE Standard Electrical Power System Device Function Numbers and Contact Designations”
- IEEE Std C37.04-1999, “IEEE Standard Rating Structure for AC High Voltage Circuit Breakers”
- ANSI/IEEE C37.04a-2003, “Standard Capacitance Current Switching Requirements for High Voltage Circuit Breakers”
- IEEE Std C37.06-2000, “American National Standard AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis- Preferred Ratings and Related Required Capabilities”
- IEEE Std C37.13-1990, “IEEE Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures”
- IEEE Std C37.14-2002, “IEEE Standard for Low-Voltage DC Power Circuit Breakers Used in Enclosures”

- IEEE Std C37.16-2000, “American National Standard Low-Voltage Power Circuit Breakers and AC Power Circuit Breakers – Preferred Ratings, Related Requirements, and Application Recommendations”

- IEEE Std C37.17-1997, “Trip Devices for AC and General Purpose DC Low-Voltage Power Circuit Breakers”

- IEEE Std C37.18-1979, “IEEE Standard Enclosed Field Discharge Circuit Breakers for Rotating Electric Machinery”

- ANSI/IEEE C37.20.1-2002, “Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear”

- IEEE Std C37.20.1A-2005, “IEEE Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear – Amendment 1: Short-Time and Short-Circuit Withstand Current Tests – Minimum Areas for Multiple Cable Connections”

- IEEE Std C37.20.2-1999, “Metal-Clad and Station-Type Cubicle Switchgear”

- IEEE Std C37.20.4-2001, “Standard for Indoor AC Switches (1 kV to 38 kV) for Use in Metal-Enclosed Switchgear”

- IEEE Std C37.20.6-1997, “IEEE Standard for 4.76 kV to 38 kV Rated Grounding and Testing Devices Used in Enclosures”

- IEEE Std C37.21-2005, “IEEE Standard for Control Switchboards”

- IEEE Std C37.22-1997, “Preferred Ratings and Related Required Capabilities for Indoor AC Medium Voltage Switches Used in Metal-Enclosed Switchgear”

- IEEE Std C37.23-2003, “IEEE Standard for Metal-Enclosed Bus”

- IEEE Std C37.26-2003, “IEEE Guide for Methods of Power Factor Measurement for Low-Voltage Inductive Test Circuits”

- IEEE Std C37.27-1987, “IEEE Standard Application Guide for Low-Voltage AC Non-Integrally Fused Power Circuit Breakers (Using Separately Mounted Current-Limiting Fuses”

- IEEE Std C37.32-2002, "High Voltage Switches, Bus Supports, and Accessories – Schedule of Preferred Ratings, Construction Guidance and Specifications"

- IEEE Std C37.81-1989, “IEEE Guide for Seismic Qualification of Class 1E Metal-Enclosed Power Switchgear Assemblies”

- IEEE Std C37.82-1987, “IEEE Standard for the Qualification of Switchgear Assemblies for Class 1E Applications in Nuclear Power Generating Stations”

- IEEE Std C37.90-2005, “IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus”
- IEEE Std C37.90.1-2002, “IEEE Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electrical Power Apparatus”
- IEEE Std C37.90.2-2004, “IEEE Standard for Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers”
- IEEE Std C37.91-2000, “IEEE Guide for Protective Relay Applications to Power Transformers”
- IEEE Std C37.96-2000, "IEEE Guide for Motor Protection"
- IEEE Std C37.98-1987, “IEEE Standard Seismic Testing of Relays”
- IEEE Std C37.105-1987, “IEEE Standard for Qualifying Class 1E Protective Relays and Auxiliaries for Nuclear Power Generating Stations”
- IEEE Std C37.106-2003, “IEEE Guide for Abnormal Frequency Protection for Power Generating Plants”
- IEEE Std C37.121-1989 (R2000), “Switchgear – Unit Substations – Requirements”
- IEEE Std C57.12.00-2000, “IEEE Standard for Standard General Requirements for Liquid-Immersed Distribution, Power and Regulating Transformers”
- IEEE Std C57.13-1993, “IEEE Standard Requirements for Instrument Transformers”
- IEEE Std C57.105-1978, “IEEE Guide for Application of Transformer Connections in Three Phase Distribution Systems”
- IEEE Std C57.109-1993, “IEEE Guide for Transformers Through-Fault Current Duration”
- IEEE Std C62.23, 1995, “IEEE Application Guide for Surge Protection of Electric Generating Plants”
- ANSI/IEEE C2-2002, National Electrical Safety Code
- NEMA MG-1, 2006, Motors and Generators
- NEMA VE-1, 2002, Metal Cable Tray Systems
- NFPA 70-2005, National Electrical Code
- NFPA 780-2004, Standard for the Installation of Lightning Protection Systems

- ICEA P-54-440/NEMA WC-51, 2003, Ampacities of Cables Installed in Cable Trays

8.1.6 Combined License Information

No additional information is required to be provided by a COL Applicant in connection with this section.

8.1.7 References

8.1-1 IEEE Standard Criteria for Diesel-Generator Units Applied as Standby Power Supplies for Nuclear Power Generating Stations, IEEE Std 387, 1995.

8.1-2 Application and Testing of Safety-Related Diesel Generators in Nuclear Power Plants, Regulatory Guide 1.9 Rev. 4, March 2007.

8.1-3 General Design Criteria for Nuclear Power Plants, NRC Regulations Title 10, Code of Federal Regulations, 10 CFR Part 50, Appendix A.

Table 8.1-1 Design Criteria and Guidelines for Electric Power Systems (Sheet 1 of 7)

Criteria Provided in Referenced Documents	DCD Section/Subsection				Remarks
	8.2	8.3.1	8.3.2	8.4	
1. 10 CFR 50 Appendix A – GDC					
a. GDC 2, “Design Bases for Protection Against Natural Phenomena”	A	A	A		
b. GDC 4, “Environmental and Dynamic Effects Design Bases”	A	A	A		
c. GDC 5, “Sharing of Structures, Systems, and Components”					Not applicable
d. GDC 17, “Electric Power Systems”	A	A	A	A	
e. GDC 18, “Inspection and Testing of Electric Power Systems”	A	A	A	A	
f. GDCs 33, 34, 35, 38, 41, and 44	A	A	A		
g. GDC 50, “Containment Design Basis”		A	A		

Note: “A” denotes that US-APWR conforms to the requirements and criteria provided in the subject document.
“G” denotes that US-APWR conforms to the guidance provided in the subject document.

Table 8.1-1 Design Criteria and Guidelines for Electric Power Systems (Sheet 2 of 7)

Criteria Provided in Referenced Documents	DCD Section/Subsection				Remarks
	8.2	8.3.1	8.3.2	8.4	
2. Regulations (10 CFR 50 and 10 CFR 52)					
a. 10 CFR 50.34, "Contents of Applications; Technical Information"					
i. 50.34(f)(2)(v) (Related to TMI Item I.D.3)					Not applicable
ii. 50.34(f)(2)(xiii) (Related to TMI Item II.E.3.1)					Not applicable
iii. 50.34(f)(2)(xx) (Related to TMI Item II.G.1)					Not applicable
b. 10 CFR 50.55a, "Codes and Standards"		A	A		
c. 10 CFR 50.63, "Loss of All Alternating Current Power"	A	A	A	A	
d. 10 CFR 50.65(a)(4), "Requirements for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants"	A	A	A	A	
e. 10 CFR 52.47(b)(1), "Contents of Applications"	A	A	A	A	
f. 10 CFR 52.80(a), "Contents of Applications; Additional Technical Information"	A	A	A	A	

Note: "A" denotes that US-APWR conforms to the requirements and criteria provided in the subject document.
"G" denotes that US-APWR conforms to the guidance provided in the subject document.

Table 8.1-1 Design Criteria and Guidelines for Electric Power Systems (Sheet 3 of 7)

Criteria Provided in Referenced Documents	DCD Section/Subsection				Remarks
	8.2	8.3.1	8.3.2	8.4	
3. Regulatory Guide					
a. RG 1.6, "Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems"		G	G		
b. RG 1.9, "Application, and Testing of Safety-Related Diesel Generators in Nuclear Power Plants"		G		G	
c. RG 1.32, "Criteria for Power Systems for Nuclear Power Plants"	G	G	G		
d. RG 1.47, "Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems"		G	G		
e. RG 1.53, "Application of the Single-Failure Criterion to Nuclear Power Plant Protection Systems"		G	G		
f. RG 1.63, "Electric Penetration Assemblies in Containment Structures for Nuclear Power Plants"		G	G		
g. RG 1.75, "Physical Independence of Electric Systems"		G	G		

Note: "A" denotes that US-APWR conforms to the requirements and criteria provided in the subject document.
"G" denotes that US-APWR conforms to the guidance provided in the subject document.

Table 8.1-1 Design Criteria and Guidelines for Electric Power Systems (Sheet 4 of 7)

Criteria Provided in Referenced Documents	DCD Section/Subsection				Remarks
	8.2	8.3.1	8.3.2	8.4	
h. RG 1.81, “Shared Emergency and Shutdown Electric Systems for Multi-Unit Nuclear Power Plants”					Not applicable
i. RG 1.106, “Thermal Overload Protection for Electric Motors on Motor-Operated Valves”		G	G		
j. RG 1.118, “Periodic Testing of Electric Power and Protection Systems”		G	G		
k. RG 1.128, “Installation Design and Installation of Vented Lead-Acid Storage Batteries for Nuclear Power Plants”			G		
l. RG 1.129, “Maintenance, Testing, and Replacement of Vented Lead-Acid Storage Batteries for Nuclear Power Plants”			G		
m. RG 1.153, “Criteria for Safety Systems”		G	G		
n. RG 1.155, “Station Blackout”	G	G	G	G	
o. RG 1.160, “Monitoring the Effectiveness of Maintenance at Nuclear Power Plants”	G	G	G	G	
p. RG 1.182, “Assessing and Managing Risk Before Maintenance Activities at Nuclear Power Plants”	G	G	G	G	
q. RG 1.204, “Guidelines for Lightning Protection of Nuclear Power Plants”	G	G			
r. RG 1.206, “Combined License Applications for Nuclear Power Plants (LWR Edition)”	G	G	G	G	

Note: “A” denotes that US-APWR conforms to the requirements and criteria provided in the subject document.
“G” denotes that US-APWR conforms to the guidance provided in the subject document.

Table 8.1-1 Design Criteria and Guidelines for Electric Power Systems (Sheet 5 of 7)

Criteria Provided in Referenced Documents	DCD Section/Subsection				Remarks
	8.2	8.3.1	8.3.2	8.4	
4. Branch Technical Position					
a. BTP 8-1, “Requirements on Motor-Operated Valves in the ECCS Accumulator Lines”		G			
b. BTP 8-2, “Use of Diesel-Generator Sets for Peaking”		G			To the extent the guidance is applicable to GTG
c. BTP 8-3, “Stability of Offsite Power Systems”	G				
d. BTP 8-4, “Application of the Single Failure Criterion to Manually Controlled Electrically Operated Valves”		G			
e. BTP 8-5, “Supplemental Guidance for Bypass and Inoperable Status Indication for Engineered Safety Features Systems”		G	G		
f. BTP 8-6, “Adequacy of Station Electric Distribution System Voltages”	G	G			
g. BTP 8-7, “Criteria for Alarms and Indications Associated with Diesel-Generator Unit Bypassed and Inoperable Status”		G			To the extent the guidance is applicable to GTG

Note: “A” denotes that US-APWR conforms to the requirements and criteria provided in the subject document.
“G” denotes that US-APWR conforms to the guidance provided in the subject document.

Table 8.1-1 Design Criteria and Guidelines for Electric Power Systems (Sheet 6 of 7)

Criteria Provided in Referenced Documents	DCD Section/Subsection				Remarks
	8.2	8.3.1	8.3.2	8.4	
5. NRC Technical Report Designation (Nuclear Regulatory Commission)					
a. NUREG-0718, Revision 1 Licensing Requirements for Pending Applications for Construction Permits and Manufacturing License		G	G		
b. NUREG-0737 Clarification of TMI Action Plan Requirements		A			
c. NUREG/CR-0660 Enhancement of Onsite Diesel Generator Reliability		G			
d. NUREG-1793 Final Safety Evaluation Report Related to Certification of the AP1000 Standard Design					Not applicable

Note: "A" denotes that US-APWR conforms to the requirements and criteria provided in the subject document.
"G" denotes that US-APWR conforms to the guidance provided in the subject document.

Table 8.1-1 Design Criteria and Guidelines for Electric Power Systems (Sheet 7 of 7)

Criteria Provided in Referenced Documents	DCD Section/Subsection				Remarks
	8.2	8.3.1	8.3.2	8.4	
6. Commission Papers (SECY)					
a. SECY-90-016 Evolutionary Light Water Reactor Certification Issues and Their Relationships to Current Regulatory Requirements, 1990	A	A		A	
b. SECY-94-084 Policy and Technical Issues Associated with the Regulatory Treatment of Non-Safety Systems in Passive Plant Designs, 1994	A	A		A	
c. SECY-95-132 Policy and Technical Issues Associated with the Regulatory Treatment of Non-Safety Systems (RTNSS) in Passive Plant Designs, 1995	A	A		A	
d. SECY-91-078 EPRI's Requirements Document and Additional Evolutionary LWR Certification Issues, 1991	A				
e. SECY-05-0227 Final Rule - AP1000 Design Certification, 2005					Not applicable

Note: "A" denotes that US-APWR conforms to the requirements and criteria provided in the subject document.
"G" denotes that US-APWR conforms to the guidance provided in the subject document.

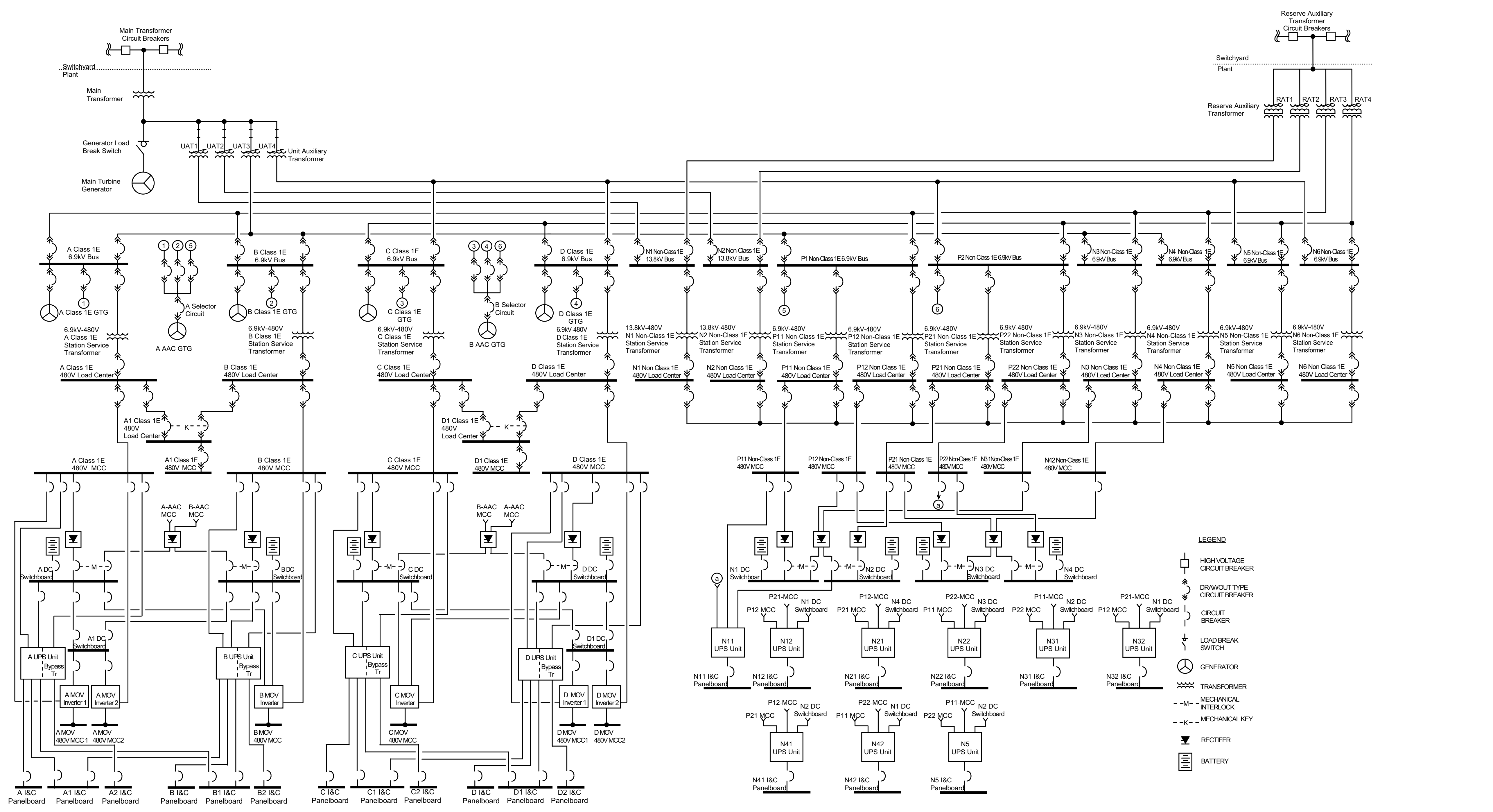


Figure 8.1-1 Simplified One Line Diagram Electric Power System

8.2 Offsite Power System

8.2.1 System Description

8.2.1.1 Transmission System

The transmission system is not within the scope of the US-APWR; however, there are design basis requirements (interface requirements) which are described in Subsection 8.2.3. The COL Applicant is to implement the transmission system interfaces for the US-APWR.

8.2.1.2 Offsite Power System

The offsite power system is a non safety-related, non-Class 1E system. The plant switchyard is connected to the transmission grid by at least two electrically independent and physically isolated power circuits. As a minimum, there are two electrically isolated and physically independent power circuits connecting the plant to the switchyard. The COL Applicant is to assure at least two electrically isolated and physically independent power circuits as normal and alternate preferred power sources.

Offsite electric power is provided to the onsite power system from the grid and other generating stations by at least two physically independent transmission lines. The plant's high voltage switchyard is site-specific and not a part of the reference plant design. During plant startup, shutdown, maintenance, and during all postulated accident conditions, offsite electric power can be supplied to the plant site from the plant high voltage switchyard through two physically independent transmission tie lines. One of these two transmission tie lines connects to the high voltage side of the MT, and the other connects to the high voltage side of the RATs. The MG is connected to the low voltage side of the MT and the high voltage side of the UATs. There is a GLBS between the MG and the MT. When the MG is on-line, it provides power to the onsite non safety-related electric power system through the UATs. When the GLBS is open, offsite power to the onsite non safety-related electric power system is provided through the MT and the UATs. With GLBS either open or closed, offsite power to the onsite safety-related electric power system is provided through the RATs. If power is not available through the UATs, offsite power is provided to both safety-related and non safety-related onsite electric power systems through the RATs. Similarly, if power is not available through the RATs, offsite power is provided to both safety-related and non safety-related onsite electric power system through the UATs. Both normal and alternate preferred power sources have the capability to serve the total plant auxiliary and service loads during all modes of plant operation including postulated accident conditions.

The MG is connected to the GLBS through an isolated phase busduct cooled by forced air with water cooling. The other side of the GLBS is connected to the low voltage side of the MT, also through an isolated phase busduct. This isolated phase busduct has a tap connection to the high voltage side of the UATs through a disconnect link. The MT consists of three single phase transformers with one installed spare.

There are two non-Class 1E 13.8 kV MV buses N1 and N2, four non-Class 1E 6.9 kV MV buses N3, N4, N5 and N6, two non-Class 1E 6.9 kV MV permanent buses P1 and P2 and four Class 1E 6.9 kV MV buses A, B, C and D. MV bus N1 can be fed from UAT1 or

RAT1. MV bus N2 can be fed from UAT2 or RAT2. MV buses N3, N4, A, B and P1 can be fed from UAT3 or RAT3. MV buses N5, N6, C, D and P2 can be fed from UAT4 or RAT4. For all these MV buses, if power is lost from one source, the buses are automatically transferred to the other source by fast or slow transfer scheme. At that time, if bus voltage is adequate, fast transfer is initiated. If this is not the case, slow transfer is initiated. Performance of these transfers is permitted when the bus faulted signal is not initiated. Detailed explanation of bus transfer scheme is described in Subsection 8.3.1.1.2.4. All low voltage buses are provided power from the MV buses. Each of the 6.9 kV Class 1E MV buses has its own onsite Class 1E standby emergency power source. Similarly, each of the 6.9 kV non-Class 1E MV permanent buses has its own onsite non-Class 1E standby emergency power source, designated as AAC power source. All MV buses can be powered from their associated UAT or RAT.

There are four, two-winding, UATs, namely UAT1, UAT2, UAT3, and UAT4. The high-side of these transformers is connected to the main generator isolated phase busduct down-stream of the GLBS. During normal power operation, with the GLBS closed, the MG provides power to the plant MV buses N1, N2, N3, N4, N5, N6, P1 and P2 through the UATs. During all other modes of plant operation, including PAs, with the GLBS open, these MV buses are powered through the UATs by back-feeding the MT from the offsite power sources. During all modes of plant operation including startup, normal and emergency shutdown and PAs, the MV Class 1E buses A, B, C and D are powered through the RATs from offsite power sources. Secondary voltages of UAT and RAT are displayed in the MCR.

There are four, three-winding RATs, namely RAT1, RAT2, RAT3, and RAT4. The high-side of these transformers is connected to the high voltage transmission tie line from the switchyard. The transmission tie line voltage level is site-specific. This is the normal preferred power source for all plant safety-related auxiliary and service loads. RAT1 and RAT2 can feed the 13.8 kV non-Class 1E buses N1 and N2, respectively. RAT3 can feed the 6.9 kV Class 1E buses A and B, and non-Class 1E buses N3, N4 and P1. RAT4 can feed the 6.9 kV Class 1E buses C and D, and non-Class 1E buses N5, N6 and P2.

Each of the safety-related and non safety-related MV buses (13.8 kV non-Class 1E buses N1 and N2; 6.9 kV Class 1E buses A, B, C, and D; and 6.9 kV non-Class 1E buses N3, N4, N5, N6, P1 and P2) is connected to a UAT and an RAT. For all Class 1E (A, B, C and D) MV buses, power from the RAT is the normal preferred source and power from the UAT is the alternate preferred source. Each safety MV bus also has its own backup emergency power supply from a safety-related Class 1E GTG. MV permanent buses P1 and P2 also have their own backup emergency power supply from a dedicated non-Class 1E GTG.

During all modes of plant operation, including normal and emergency shutdown and postulated accident conditions, all safety-related unit auxiliary and safety-related plant service loads are powered from offsite power sources through the RATs. This is the normal preferred offsite power source for the plant safety-related loads. The alternate preferred offsite power source to the plant safety-related loads is from the UATs, which are powered from offsite power sources by back feeding the MT. All plant MV buses, both safety-related and non safety-related, are connected to the UATs and RATs through bus incoming circuit breakers. If power to any MV bus is lost from the normal source, it is automatically transferred to the alternate source. If any one UAT becomes inoperable, it can be isolated from the system and the affected MV buses can be powered from the backup RAT.

During a coincident loss of offsite power (LOOP) and loss-of-coolant accident (LOCA), the safety-related MV buses are powered from onsite Class 1E emergency GTG power sources. The unit is also provided with alternate ac power sources for powering the loads that are needed to operate during a station blackout (SBO) event. The equipment and circuits that are associated with the offsite power system are physically independent from the onsite power system and the alternate ac sources. Any single failure in the offsite power system, in the onsite power system, or in the AAC sources will have no impact on the availability of the remaining systems.

The main transformers, UATs and RATs are designed and constructed to withstand mechanical and thermal stresses produced by the worst-case external short circuit, and meet the corresponding requirements of IEEE Std C57.12.00 (Reference 8.2-1).

The ratings of the MG, the GLBS, the MT, the UATs and the RATs are as follows:

Equipment	Rating
Main generator	1,900 MVA, 26 kV, 60 Hz
Generator load break switch	28 kV, 44.4 kA, 60 Hz
Main transformer	Three single phase transformers and one installed spare, each 610 MVA for a combined rating of 1,830 MVA, 60 Hz, low voltage side is 26 kV, high voltage side is site-specific.
Unit auxiliary transformers (UAT1 and UAT2)	72 MVA, 26 – 13.8 kV, 60 Hz
Unit auxiliary transformers (UAT3 and UAT4)	53 MVA, 26 – 6.9 kV, 60 Hz
Reserve auxiliary transformers (RAT1 and RAT2)	72 MVA, 60 Hz, low voltage side 13.8 kV, high voltage side is site-specific.
Reserve auxiliary transformers (RAT3 and RAT4)	53 MVA, 60 Hz, low voltage side 6.9 kV, high voltage side is site-specific.

The GLBS has the capability to break the maximum credible generator full load current. For normal or emergency plant shutdown for all design-basis events (DBE) except for an electrical fault in the 26 kV power system or associated equipment and circuits, the GLBS is opened and power to all auxiliary and service loads is maintained without any interruption from the alternate preferred offsite power source through the UATs. During 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.

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 manholes. The manholes are available for temporary sump pumps for water draining. The medium voltage cables whether in a duct bank or in a conduit are monitored by periodical testing, such as partial discharge testing, time domain reflectometry, dissipation factor testing, and very low frequency AC testing. These PPS circuits are also designed to minimize common cause failure with standby power sources. All of these transformers are provided with containment for collection of transformer oil in case of tank leakage or rupture.

8.2.1.2.1 Switchyard

The plant switchyard design is site-specific. The COL Applicant is to provide at least two physically independent power circuits between the offsite grid systems and the plant's high voltage switchyard. The design of the interface is to be provided by the COL Applicant. There are two physically independent transmission tie lines from the plant high voltage switchyard to the onsite transformer yard. These two power circuits are designed and located to minimize, to the extent practical, the likelihood of their simultaneous failure under operating condition and postulated accident conditions. Each power circuit has sufficient capacity and capability to assure satisfactory operation of all safety-related loads and non safety-related loads.

All relay systems used for protection of offsite power circuits and transformers are provided with primary and back-up protection. The COL Applicant is to provide protection relaying of offsite power circuits.

8.2.2 Analysis

The preferred offsite power system is designed consistent with the following criteria, so far as they are applicable to non-Class 1E equipment and system. Any exceptions or clarifications to the applicable criteria are explained.

8.2.2.1 Applicable Criteria

- GDC 2, "Design Bases for Protection Against Natural Phenomena"

  Equipment and components of the offsite power system are non-Class 1E and are located outdoors except for the connections to Class 1E MV buses, which are located indoors. The effects of natural phenomena are considered in designing the offsite power system to withstand without loss of capability to perform their intended functions within the conditions as provided in Chapter 2 such as high and low atmospheric temperatures, high wind, rain, ice and snow, but it not specifically designed to withstand earthquakes, tornadoes, hurricanes or floods. Lightning protection of the offsite power system is described in conformance with RG 1.204 (Reference 8.3.1-16). The normal and alternate preferred offsite power circuits are physically separated and electrically isolated, so that failure of an active component in one circuit has no impact to the on the other circuit.

- GDC 4, "Environmental and Dynamic Effects Design Bases"

  All equipment and components of the offsite power system are designed to withstand the effects of, and are operable under the environmental conditions associated with normal conditions, maintenance, testing and postulated accidents; and are appropriately protected against dynamic effects that may result from equipment failures, including missiles, pipe whipping and discharging fluids. Each transformer of the offsite power system is provided with its own oil containment system, and accidental oil leakage from one transformer has no impact on the remaining transformers. There are no high or moderate energy lines or missile generating rotating equipment in the vicinity of the equipment and components of the offsite power system. The offsite power system design conforms to the criteria of IEEE Std 765 (Reference 8.2-2).

- GDC 5, "Sharing of Structures, Systems and Components," and RG 1.81 (Reference 8.2-3), "Shared Emergency and Shutdown Electric Systems for Multi-Unit Nuclear Power Plants"

  The US-APWR reference plant is designed as a single-unit plant, and therefore, GDC 5 and RG 1.81 (Reference 8.2-3) are not applicable.

- GDC 17, "Electric Power Systems"

  The offsite power system design fully conforms to the requirements of GDC 17. There are two physically independent and electrically isolated power supply circuits that provide power to the onsite power system supplying all safety-related and non safety-related loads. The offsite power system and the onsite power system are independent of each other and the failure of one will have no impact on the availability of the other. Both normal preferred and alternate preferred power circuits have sufficient capacity and capability for functioning of all structures, systems, and components (SSCs) important to safety. Subsequent to a unit trip due to a LOCA, the power source for the Class 1E buses continues to be the normal preferred offsite power circuit through the RATs. The alternate preferred source also remains available through the UATs. Thereby, both offsite power supply circuits are immediately accessible for performance of all safety functions, exceeding the GDC requirement that one circuit is to be immediately accessible. For a unit trip due to an electrical fault in the alternate preferred offsite power system, the power source for the Class 1E buses is not affected since they are fed from the normal preferred offsite power supply circuit (from RAT).

  Even though the normal and alternate preferred power circuits are designed and located to minimize, to the extent practical, the likelihood of their simultaneous failure under operating conditions and postulated accident and environmental conditions, the offsite power system is a non-Class 1E non safety-related system. The offsite power system by itself is not designed to meet the single failure criterion, while the onsite power system design meets the single failure criterion. Considering both offsite and onsite power systems together, the design not only meets the single failure criterion but also provides capability of sustaining a double failure, one of which is a complete loss of offsite power, the other single failure of onsite power source, without losing the capability to provide power for the minimum required safety functions.

- GDC 18, "Inspection and Testing of Electric Power Systems"

  Compliance with this criterion is achieved by designing testability and inspection capability into the system and then implementing a comprehensive testing and surveillance program. Inspection and testing of the high voltage circuit breakers at the switchyard powering the transmission tie lines, and protective relaying can be conducted on a routine basis without removing any of the UATs, RATs, or transmission tie lines from service.

- GDC 33, 34, 35, 38, 41 and 44

  These GDCs set forth requirements for the safety systems for which the access to both onsite and offsite power sources must be provided. With respect to the offsite power system, the requirements of these GDCs are satisfied if the requirements of GDC 17 are met. Since the US-APWR offsite power system design fully conforms to the design requirements of GDC 17, it therefore meets the requirements of these GDCs.

- 10 CFR 50.63, “Loss of All Alternating Current Power”

  The US-APWR has two alternate ac sources located at the site for coping with an SBO. Each AAC source has adequate capacity to cope with an SBO. The offsite power system has no interface with the alternate ac sources. The equipment and circuits associated with the offsite power system and the alternate ac source are physically separated and have minimum potential for any common mode failure. There are no electrical ties between the offsite power system and the alternate ac source.

- RG 1.32, “Criteria for Power Systems for Nuclear Power Plants”

  This RG endorses IEEE Std 308 (Reference 8.2-4) except for sharing safety-related power systems in multi-unit nuclear plants. The US-APWR offsite power supply design fully confirms to the requirements of IEEE Std 308 (Reference 8.2-4) that pertain to the offsite power system.

- RG 1.155, “Station Blackout”

  This regulatory guide provides guidance for complying with 10 CFR 50.63 (Reference 8.2-5). The plant has two AAC power sources, of which only one is required to be operational to cope with an SBO event. Power supply to all electrical loads that are required to be operational is restored within 60 minutes from the onset of an SBO event. Under normal plant operating conditions, both safety and non safety dc power systems derive power from the battery chargers that are fed from the safety and non safety 480V MCCs. Safety and non safety batteries will provide power to the dc power system during the first 60 minutes of an SBO event. Within 60 minutes of an SBO event, power from AAC sources would be available to the required battery chargers and the dc systems will be powered from the associated battery chargers. Hence, for an SBO condition, the batteries are required to be sized to provide their duty cycle current for a period of 60 minutes. The Class 1E batteries for the US-APWR are sized for the worst case duty cycle requirements for a period of two hours, considering loss of associated battery charger and plant conditions that include normal plant operation, LOOP, LOOP concurrent with LOCA and SBO.

- RG 1.160, “Monitoring the Effectiveness of Maintenance at Nuclear Power Plants”

  This regulatory guide endorses revision 2 of NUMARC 93-01 with some provisions and clarifications for complying with 10 CFR 50.65 (Reference 8.2-7). Conformance to this regulatory guide is generically addressed in Section 1.9.

- RG 1.182, “Assessing and Managing Risk Before Maintenance Activities at Nuclear Power Plants”

  This RG endorses Section 11 of NUMARC 93-01 (Reference 8.2-6) dated February 11, 2000 with some provisions and clarifications for complying with 10 CFR 50.65(a)(4) (Reference 8.2-7). Conformance to this regulatory guide is generically addressed in Section 1.9.

- RG 1.204, “ Guidelines for Lightning Protection of Nuclear Power Plants”

  This RG endorses four IEEE Standards, IEEE Std 665 (Reference 8.2-8), IEEE Std 666 (Reference 8.2-9), IEEE Std 1050 (Reference 8.2-10) and IEEE Std C62.23 (Reference 8.2-11), in their entirety with one exception to IEEE Std 665 (Reference 8.2-8), Subsection 5.7.4, which misquotes subsection 4.2.4 of IEEE Std 142 (Reference 8.2-12). The US-APWR offsite power supply design fully conforms to the requirements of the endorsed IEEE standards that pertain to the lightning protection of nuclear power plants.

- Standard Review Plan (SRP) Section 8.2 Appendix A

  The US-APWR has GLBS which conforms to the requirement of the SRP Section 8.2 Appendix A. In addition, the Class 1E MV buses are normally supplied from RAT as normal PPS. Therefore, immediate access circuit is assured without isolating the main generator from MT and UAT in case of electrical fault in the power supply circuit affecting the UATs.

- BTP 8-3, “Stability of Offsite Power Systems”

  This topic is site-specific (see Subsection 8.2.4, Combined License Information).

- BTP 8-6 “Adequacy of Station Electric Distribution System Voltages”

  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 reactor coolant pump (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.

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 study to confirm this interface requirement.

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.

The above electrical design and configuration ensures power to RCPs for more than 3 seconds when a unit trip occurs.

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.

COL 8.2(12) *Deleted*

8.2.5 References

8.2-1 IEEE Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers, IEEE Std C57.12.00, 2000.

8.2-2 IEEE Standard for Preferred Power Supply (PPS) for Nuclear Power Generating Stations (NPGS), IEEE Std 765, 2006.

8.2-3 Shared Emergency and Shutdown Electric Systems for Multi-Unit Nuclear Power Plants, Regulatory Guide 1.81 Revision 1, January 1975.

8.2-4 IEEE Standard Criteria for Class 1E Power Systems for Nuclear Power Generating Stations, IEEE Std 308, 2001.

8.2-5 Loss of all alternating current power, NRC Regulations Title 10, Code of Federal Regulations, 10 CFR Part 50.63.

8.2-6 Industry Guideline for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants, NUMARC 93-01, 2000.

8.2-7 Requirements for monitoring the effectiveness of maintenance at nuclear power plants, NRC Regulations Title 10, Code of Federal Regulations, 10 CFR Part 50.65.

8.2-8 IEEE Standard for Generating Station Grounding, IEEE Std 665, 1995.

8.2-9 IEEE Design Guide for Electric Power Service Systems for Generating Stations, IEEE Std 666, 1991.

8.2-10 IEEE Guide for Instrumentation and Control Equipment Grounding in Generating Stations, IEEE Std 1050, 1996.

8.2-11 IEEE Application Guide for Surge Protection of Electric Generating Plants, IEEE Std C62.23, 1995.

8.2-12 IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems, IEEE Std 142, 1991.

8.2-13 Definitions, NRC Regulations Title 10, Code of Federal Regulations, 10 CFR Part 50.2.

8.2-14 IEEE Application Guide for ac High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis, IEEE Std C37.010, 1999.

8.2-15 AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis - Preferred Ratings and Related Required Capabilities, IEEE Std C37.06, 2000.

8.2-16 High Voltage Switches, Bus Supports, and Accessories – Schedule of Preferred Ratings, Construction Guidance and Specifications, IEEE Std C37.32, 2002.

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

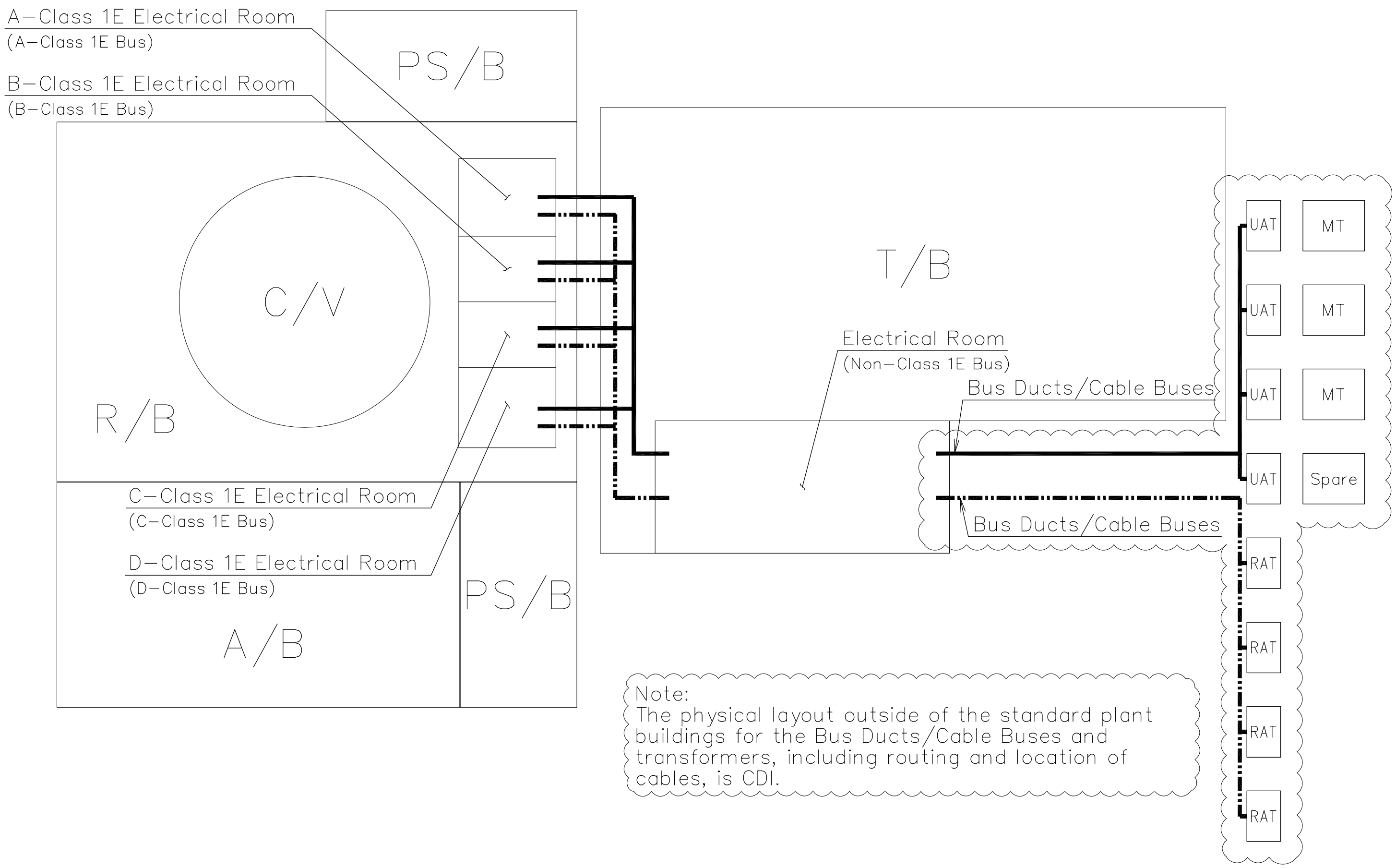


Figure 8.2-1 Layout drawing showing MT, UAT, RAT, MV Buses

8.3 Onsite Power Systems

The onsite power system provides power to the plant auxiliary and service loads during all modes of plant operation. The onsite power system consists of both ac power system and dc power system. Both ac and dc systems include Class 1E and non-Class 1E systems. The onsite ac power system and its connections to the offsite power system are shown in Figure 8.3.1-1. The Class 1E and non-Class 1E dc power systems are described in Subsection 8.3.2.

8.3.1 AC Power Systems

8.3.1.1 Description

The onsite ac power system includes normal power systems powered from the offsite power sources, emergency power systems backed-up by Class 1E GTGs and permanent power systems backed-up by non-Class 1E AAC GTGs.

The onsite ac power system is supplied offsite power from the transmission system by two independent connections to the transmission system (The transmission voltages are site-specific). Each offsite power connection has enough capacity and capability to power the loads required during all modes of plant operation, including the plant startup, shutdown, maintenance and postulated accident conditions. One connection to the transmission system is provided through the MT and UATs. The UATs are also connected to the MG through a GLBS. During power operation mode, GLBS is closed and the MG is connected to the transmission system through the MT and also supplies power to the UATs. The second connection to the transmission system is provided through the RAT. The voltage of the high voltage winding of the RAT is site-specific. The onsite ac power systems are normally fed from either the UATs or RATs. The MV Class 1E buses are normally fed from the RATs. MV non-Class 1E buses are normally fed from the UATs.

Four two-winding UATs and four three-winding RATs are provided for each unit. Delta connected tertiary winding is provided for the star-star connected RATs. The tertiary winding is not loaded. The UATs are connected on the high voltage side to the IPB through disconnecting links. The disconnecting links are always closed except during UAT maintenance. UAT1, UAT2, RAT1 and RAT2 provide power to the 13.8kV onsite ac buses and UAT3, UAT4, RAT3 and RAT4 provide power to the 6.9kV onsite ac buses.

Four emergency Class 1E GTGs provide backup power to the Class 1E 6.9kV onsite ac buses. In addition, two non-Class 1E AAC GTGs provide backup power to the non-Class 1E 6.9kV permanent buses.

The onsite ac power system provides power at nominal voltage ratings of 13.8kV, 6.9kV, 480V, 208V, and 120V, ac. The 13.8kV power system is non safety-related and non-Class 1E. The 6.9kV, 480V 208V, and 120V ac power systems include both safety-related Class 1E and non safety-related non-Class 1E systems. The onsite ac power system arrangement shown in Figure 8.3.1-1 permits distribution of functionally redundant load groups on separate buses for better equipment availability and operational flexibility.

8.3.1.1.1 Non-Class 1E Onsite AC Power System

The 13.8kV ac system includes non-Class 1E buses N1 and N2. Bus N1 is connected to either UAT1 or RAT1 and bus N2 is connected to either UAT2 or RAT2 by non-segregated busduct/cable buses. The ratings of UAT1, UAT2, RAT1 and RAT2 are shown in Table 8.3.1-1.

The non-Class 1E 6.9kV ac system includes buses N3, N4, N5, N6, P1 and P2. Buses N3, N4 and P1 are connected to either UAT3 or RAT3 and buses N5, N6 and P2 are connected to either UAT4 or RAT4 by non-segregated busduct/cable buses. The ratings of UAT3, UAT4, RAT3 and RAT4 are shown in Table 8.3.1-1.

The UAT and RAT ratings are adequate to meet the maximum load requirements during normal plant operation, start-up, shutdown and design-basis events, as shown in Table 8.3.1-3.

Non-Class 1E 6.9kV permanent buses P1 and P2 are also connected to the non-Class 1E A-AAC GTG and B-AAC GTG, respectively. The loads which are not safety-related but require operation during LOOP are connected to these buses. A different manufacturer is adopted for the AAC GTGs to minimize common cause failures with the Class 1E GTGs. The AAC GTGs are provided with diverse starting mechanisms as compared to the Class 1E GTGs. The AAC GTGs are started by dc supplied from batteries and the Class 1E GTGs are started by a compressed air system. Rating of AAC GTG is shown in Table 8.3.1-1. Any one AAC GTG is adequate to meet the load requirements shown in Table 8.3.1-5 and Table 8.3.1-6 during LOOP and SBO conditions.

Normal offsite power to the non-Class 1E 13.8kV buses N1, N2 and non-Class 1E 6.9kV buses N3, N4, N5, N6, P1 and P2 is provided from the UATs and alternate offsite power is provided from the RATs. Automatic bus transfer schemes are provided on all these buses to automatically transfer the loads from the normal offsite power source to the alternate offsite power source in case of loss of normal power to the buses.

Logic schemes for the automatic fast and slow bus transfer of offsite power from UAT to RAT for non-Class 1E MV buses N1, N2, N3, N4, N5, N6, P1 and P2 are shown in Figure 8.3.1-2. Restoration of power from the alternate offsite source back to normal offsite source is by manual operation.

LOOP condition occurs if power from both the UAT and RAT is lost to the onsite ac power system buses. Motor loads fed from these buses are tripped by the bus undervoltage relays. However, power to the non-Class 1E 6.9kV ac permanent buses P1 and P2 is automatically restored from the A-AAC GTG and B-AAC GTG respectively. The A-AAC GTG is started automatically by the undervoltage relays on bus P1 and B-AAC GTG is started automatically by the bus undervoltage relays on bus P2 during the LOOP condition. As soon as the AAC GTGs reach their preset voltage and frequency limits, the circuit breakers connecting the A-AAC GTG and B-AAC GTG to their respective selector circuits A and B are closed, as shown in Figure 8.3.1-2. The circuit breakers in the 6.9kV switchgears P1 and P2 and the circuit breakers in the selector circuits A and B, connecting the 6.9kV bus P1 to selector circuit A and bus P2 to selector circuits B are normally closed. Therefore, power to the 6.9kV buses P1 and P2 is restored as soon as the circuit breaker connecting A-AAC GTG to selector circuit A and B-AAC GTG to selector circuit B are closed. The automatic load sequencer starts the loads on the permanent buses P1 and P2 as required under LOOP condition as shown in Figure 8.3.1-2.

The A-AAC GTG and B-AAC GTG can also be connected manually to their respective 6.9kV permanent buses P1 and P2 during periodic online testing of the AAC GTGs. This can be done locally from the panels located in the power source buildings (PS/Bs) housing the AAC GTGs, or remotely from the main control room (MCR).

13.8kV-480V, two winding SSTs connected to the 13.8kV buses N1 and N2 provide power to the non-Class 1E 480V load center buses N1 and N2 respectively.

6.9kV-480V, two winding SSTs connected to the 6.9kV buses N3, N4, N5, N6, P1 and P2 provide power to non-Class 1E 480V load center buses N3, N4, N5, N6, P11, P12, P21 and P22 respectively. The non-Class 1E 480V load center buses feed the non-Class 1E MCC buses.

A tie connection is provided between all these non-Class 1E 480V load center buses so that in case of loss of power from any one of the non-Class 1E SSTs, the loads on the affected load center bus can be transferred manually to any of the remaining operable load center buses.

The reactor coolant pump (RCP) motors are connected to the non-Class 1E 6.9kV switchgear buses N3, N4, N5 and N6 through two circuit breakers in series. One circuit breaker is located in the reactor building (R/B) and it is qualified for Class 1E application. The other circuit breaker has the same quality and is located in non-Class 1E 6.9kV switchgear in the T/B, as shown in Figure 8.3.1-1.

The non-Class 1E 13.8kV switchgear N1, N2, 6.9kV switchgear N3, N4, N5, N6, P1 and P2 and 480V load centers N1, N2, N3, N4, N5, N6, P11, P12, P21 and P22 are located in the T/B electrical room as shown in Table 8.3.1-9. Status of these circuit breaker is displayed in the MCR.

The A-AAC GTG and B-AAC GTG are located in separate rooms in the PS/B. The rooms for the A-AAC GTG and B-AAC GTG are physically separated from each other and also from the Class 1E GTG rooms as shown in the Figure 8.3.1-4. The non-Class 1E AAC GTGs are of different manufacturer compared to the Class 1E GTGs and do not share any common auxiliaries or support systems with the Class 1E GTGs. This minimizes common-cause failure between the AAC GTGs and the Class 1E GTGs. Each AAC GTG is provided with a 1.5 hour fuel oil day tank and a fuel oil storage tank. The fuel capacity is adequate for 7 days operation. During SBO, the power to the Class 1E buses A or B is restored manually from A-AAC GTG by closing the circuit breaker in the selector circuit A and the circuit breaker in the Class 1E 6.9kV switchgear A or B, to cope with the SBO condition. Similarly, during SBO, the power to the Class 1E buses C or D can also be restored manually from the B-AAC GTG by closing the circuit breaker in the selector circuit B and the circuit breaker in the Class 1E 6.9kV switchgear C or D, to cope with the SBO condition. Only one safety train is required for coping with the SBO event. Table 8.3.1-6 shows the loading on AAC GTG during the SBO. Details of switching operations to restore power to the Class 1E power system during SBO are included in Section 8.4.

The UATs and RATs are protected with differential relays for internal faults and time overcurrent relays as backup protection. The incoming circuit breakers to the non-Class 1E 13.8kV and 6.9kV buses are provided with undervoltage and time overcurrent protections. The feeders on 13.8kV and 6.9kV buses are provided with instantaneous and time overcurrent protection.

8.3.1.1.2 Class 1E Onsite AC Power System

The Class 1E onsite ac power systems provide power to the safety-related loads required during LOOP and postulated accident conditions. The power from the transmission system to the Class 1E distribution is the preferred power source under accident and post-accident conditions. The Class 1E onsite ac power system consists of four independent and redundant trains A, B, C and D as shown in Figure 8.3.1-1. Two independent connections to the offsite power system are provided to each of the Class 1E 6.9kV ac onsite buses A, B, C and D. Class 1E 6.9kV buses A and B have connections to UAT3 and RAT3, and buses C and D have connections to UAT4 and RAT4 through non-segregated busducts/cable buses. Each redundant train is backed-up by a Class 1E GTG. The four trains are physically separated and electrically isolated from each other and also from the non-Class 1E systems in accordance with IEEE Std 384 (Reference 8.3.1-1) as endorsed by RG 1.75 (Reference 8.3.1-2).

6.9kV-480V, two winding SSTs connected to the Class 1E 6.9kV buses A, B, C and D provide power to Class 1E 480V load center buses A, B, C and D respectively. The Class 1E 480V load center buses feed the Class 1E MCC buses except for the Class 1E 480V ac MOV MCCs, which are supplied from the inverters. The A MOV MCC1, A MOV MCC2, B MOV MCC, C MOV MCC, D MOV MCC1 and D MOV MCC2 are fed from the Class 1E 125V dc buses as shown in Figure 8.1-1.

Class 1E onsite ac power system includes 6.9kV, 480V and 120V ac systems. Each bus voltage is indicated in the MCR.

8.3.1.1.2.1 System Redundancy

The Class 1E 6.9kV bus in each train is provided with offsite power from two connections to the transmission system; one through the RAT and the other through the UAT. Normal preferred offsite power is provided from the RATs and the alternate preferred offsite power is provided from the UATs. Each offsite power circuit is capable of supplying the Class 1E load requirements during all plant operating conditions, anticipated operational occurrences and the DBEs. Any two Class 1E trains including the power sources are adequate to supply the loads required during LOOP and LOCA conditions occurring simultaneously.

Class 1E 6.9kV buses A, B, C and D are backed-up by Class 1E GTGs A, B, C and D respectively. The rating of Class 1E GTG is shown in Table 8.3.1-1. In case of LOOP to any Class 1E 6.9kV bus, the undervoltage relays on the bus trip all the motor loads connected to the affected bus and start the Class 1E GTG associated with that bus. Power to the Class 1E bus is restored automatically by closing the Class 1E GTG circuit breaker after the Class 1E GTG reaches set voltage and frequency limits. Required loads on the bus are automatically started in sequence by the load sequencer. Detailed logic schemes for initiating Class 1E GTG starting, load shedding and load sequencing are shown in Figure 8.3.1-2.

The 6.9kV-480V Class 1E SSTs A, B, C and D provide power to the 480V Class 1E load centers A, B, C and D respectively.

Four train safety system loads are distributed on the four redundant Class 1E trains A, B, C and D. Four train safety system loads (e.g. safety injection pumps, containment spray/residual heat removal pump, essential service water pump, component cooling water pump) are designed to perform their function with any two out of four as described in Chapters 6 and 9. Two train safety system loads are distributed on Class 1E 480V buses A1 and D1. A1 buses are train A and can be powered from train B. Similarly, D1 buses are train D and can be powered from train C. Prior to a maintenance outage of train A GTG, the A1 load center is manually connected to the train B Class 1E 480V load center. Similarly, prior to a maintenance outage of train D GTG, the D1 load center is manually connected to the train C Class 1E 480V load center. The I&C power supply system contains panelboards A1, B1, C1 and D1 which can be supplied from their own train UPS and from their alternate train UPS. Prior to a maintenance outage of the own train GTG that supplies these panelboards, the panelboards are manually connected to the UPS of the alternate train. An example methodology of how physical independence and redundancy are maintained during GTG maintenance outages is included in the RG 1.75 conformance discussion of Subsection 8.3.1.2.2.

Availability of power from any two trains is adequate to meet the load requirements during all design-basis events such as LOOP and LOCA occurring simultaneously. No automatic tie connections are provided between the redundant Class 1E trains A, B, C and D. Distribution of loads on the Class 1E ac buses A, B, C and D are shown in Table 8.3.1-4, 7 and Figure 8.3.1-1.

Class 1E 6.9kV buses A, B, C and D are also provided with connections to the 6.9kV non-Class 1E AAC GTGs A and B. Class 1E 6.9kV buses A or B can be connected to the A-AAC GTG, and Class 1E 6.9kV buses C or D can be connected to the B-AAC GTG during SBO condition. Switching operations to restore power to the Class 1E power system during SBO are described in Section 8.4.

8.3.1.1.2.2 System Independence

Two independent connections to the offsite power system are provided to each of the 6.9kV ac onsite Class 1E buses A, B, C and D. These two connections are designed and located to minimize, to the extent practical, the likelihood of their simultaneous failure under operating, postulated accident and environmental conditions. The connections from the non-Class 1E offsite power sources are electrically isolated from the Class 1E buses through Class 1E circuit breakers in the Class 1E 6.9kV switchgear. In case of loss of power from the RATs to any Class 1E 6.9kV bus, the bus is automatically transferred to the UAT if available, or the associated Class 1E GTG is started. The automatic bus transfer, load shedding and load sequencing schemes for the redundant Class 1E trains A, B, C and D are independent. The logic scheme for bus transfer is shown in Figure 8.3.1-2.

The connections between the Class 1E 6.9kV buses and non-Class 1E AAC GTGs A and B are provided through two isolation devices in series which are normally open; one Class 1E circuit breaker provided at the Class 1E 6.9kV switchgear end and the other non-Class 1E circuit breaker at the non-Class 1E selector circuits A and B. The connections between the Class 1E 6.9kV buses and non-Class 1E selector circuits are administratively controlled and are closed manually during SBO condition. Class 1E 6.9kV buses A or B can be connected to the A-AAC GTG, and Class 1E 6.9kV buses C or D can be connected to the B-AAC GTG, during SBO condition. The major Class 1E distribution equipment of train A, B, C and D are physically separated by different rooms as shown in Figure 8.3.1-4. Redundant safe shutdown components and associated redundant Class 1E electrical trains are separated from the other Class 1E and non-Class 1E systems by 3-hour rated fire barriers to preserve the capability to safely shutdown the plant following a fire (Subsection 9.5.1.1). Access to the Class 1E power equipment areas is administratively controlled. The R/B and safety-related PS/Bs are structurally designed to meet seismic category I requirements as defined in RG 1.29 (Reference 8.3.1-3). These structures are designed to withstand the effects of natural phenomena such as hurricanes, floods, tornados, tsunamis, and earthquakes without loss of capability to perform safety functions. They are also designed to withstand the effects of postulated internal events such as fires and flooding without loss of capability to perform safety functions (Subsection 1.2.1.2.11). The orientation of the R/B and safety-related PS/Bs where Class 1E onsite power system components are located, is such that the probability of a turbine missile striking the R/B or PS/Bs is minimum. The Class 1E onsite power system components are also protected from internally generated missiles, tornado generated missiles and hurricane generated missiles. Safety-related components are protected against dynamic effects, including the effects of missiles, pipe whipping, and discharging fluids as a result from equipment failure or events and conditions outside the nuclear power unit. Class 1E equipment important to safety will be protected from the dynamic effects of pipe rupture and are capable of performing their intended safety functions (Subsection 3.6.1).

Auxiliary support systems such as fuel oil systems, compressed air systems and control power supplies are also separate and independent for each Class 1E train. The Class 1E power to the auxiliary support systems is derived from the same train they serve. The heating, ventilation, and air conditioning (HVAC) systems that support operation of the Class 1E ac distribution equipment are powered from the redundant Class 1E ac power system as described in Subsection 9.4.5.

The four Class 1E trains are electrically isolated from the offsite power supplies and each other. The power sources to Class 1E 6.9kV buses are not operated in parallel except for a short period of time during the testing of Class 1E GTGs in parallel with an offsite source. There are no automatic tie connections between the redundant Class 1E trains. The manual tie connection between train B load center and train A load center A1, and between train C load center and train D load center D1 are closed manually, only during the maintenance of the Class 1E A-GTG or Class 1E D-GTG. Each I&C power system has similar panelboards, which can be supplied from two different trains. The tie connection between different trains that supply the panelboards are closed manually, only during the maintenance of a Class 1E GTG. The tie circuit breakers are key operated to limit possibility of cross tie during normal operation; however, they allow for a live transfer during online maintenance of a GTG.

Non-Class 1E loads, except for the emergency lighting, pressurizer heater circuits, diverse automatic actuation cabinet, some solenoid valves and loads which require Class 1E power source for associating safety, are not supplied from the Class 1E power systems. The circuits for non-Class 1E loads are electrically isolated from the Class 1E power system by Class 1E isolation devices. Pressurizer heater Back-up groups are supplied from the Class 1E power systems based on 10 CFR 50.34(f)(2)(xiii).

Independent cable routes are provided for each Class 1E train in conformance with IEEE Std 384 (Reference 8.3.1-1), as endorsed by RG 1.75 (Reference 8.3.1-2), to preclude failure in redundant trains.

The power supply arrangement described above ensures that the physical separation and electrical isolation of redundant Class 1E trains is not compromised and any single failure in one train does not affect the redundant trains.

8.3.1.1.2.3 Single Failure Criteria

The onsite ac power system is capable of performing its safety function assuming a single failure. Electrical and physical separation of redundant power sources and associated distribution systems are described in Subsections 8.3.1.1.2.1 and 8.3.1.1.2.2. The onsite ac power system has been designed to conform to the single failure criterion requirements provided in IEEE Std 603 as endorsed by RG 1.153 (Reference 8.3.1-5).

The components of the redundant Class 1E ac systems are independent, physically separated and electrically isolated. The Class 1E 6.9kV switchgear, 480V load centers, motor control centers and 120V ac I&C power supply equipment belonging to redundant train A, B, C and D are physically separated and located in separate rooms in the R/B. The Class 1E GTGs are located in separate rooms in the PS/Bs (Figure 8.3.1-4). All safety-related electrical equipment of the onsite ac power system meets the qualification requirements of IEEE Std 323 (Reference 8.3.1-6) and applicable equipment qualification standards.

No automatic tie connections are provided between the redundant trains of Class 1E ac systems. The power and control circuits belonging to redundant Class 1E trains and their associated circuits are routed in four independent routes. Minimum separation between different trains of the Class 1E circuits, and also between Class 1E and non-Class 1E circuits meet the requirements of IEEE Std 384 (Reference 8.3.1-1) and RG 1.75 (Reference 8.3.1-2). Class 1E circuits of redundant trains are protected so that failure of the equipment of one train cannot disable Class 1E circuits or equipment essential to the performance of the safety function by the redundant train(s).

The auxiliary support systems e.g., control power, fuel systems etc. for the redundant trains of Class 1E power systems, are separate and independent. The control power supplies for each of the redundant trains are derived from their own train. The ventilation for the areas housing the Class 1E power supply equipment is provided by four redundant safety-related HVAC systems. The Class 1E GTGs do not share any common systems. Each Class 1E GTG is provided with separate and dedicated systems for control and protection, starting, ventilation and fuel supply.

The above arrangement of redundant Class 1E power systems ensures that a single failure in one train will have no impact on the availability of the remaining three trains to perform the required safety function. For any DBE, only two trains are sufficient for safe shutdown of the plant.

8.3.1.1.2.4 Manual and Automatic Interconnections between Buses, Load Shedding and Load Sequencing

The Class 1E 6.9kV buses A, B, C and D can be connected to any of the following four sources of power:

- Normal preferred offsite power from RAT
- Alternate preferred offsite power from UAT
- Standby power from Class 1E GTG and
- AAC power from non-Class 1E AAC GTG

Class 1E 6.9kV ac buses A, B, C and D are normally powered from the RAT during all modes of plant operation including normal and emergency shutdown, and accident conditions. Bus transfer schemes are provided to automatically restore power to the Class 1E buses from the alternate preferred offsite source, if available, or from the Class 1E GTG. Transfer back to RAT is by manual operation. The incoming circuit breakers to the Class 1E buses can be operated by the automatic bus transfer scheme or by manual control from the MCR or remote shutdown room. The AAC GTG incoming breaker in the Class 1E switchgear has only local manual control.

The logic diagrams for initiating closing and tripping of the incoming breakers to the Class 1E 6.9kV buses A, B, C and D are shown in Figure 8.3.1-2.

A. Automatic fast transfer of Class 1E buses from RAT to UAT

Automatic fast transfer for Class 1E buses A, B, C and D, from RAT to UAT, is initiated by opening of incoming breaker from RAT. The fast bus transfer is accomplished under the following conditions:

- Main generator protection lockout relays A and B have not operated.
- Class 1E 6.9kV bus protection relay has not operated.
- The synchronizing check relay between UAT and RAT gives permissive for the transfer.
- The incoming circuit breaker from RAT is open.

The loads on the affected bus continue operation without interruption, if the fast bus transfer from RAT to UAT is successful. If the fast bus transfer is not successful, bus undervoltage signal initiates slow transfer as shown below:

- The bus undervoltage signal trips the incoming circuit breaker from RAT and starts the Class 1E GTG associated with the affected bus.
- Trip the motor loads on the affected bus.
- Close the incoming circuit breaker from the UAT after 1 second, if incoming circuit breaker from RAT is open and the 6.9kV bus protection relay has not operated. If the voltage to the affected Class 1E buses is restored from the alternate offsite power through UAT, loads on the affected buses are started by the LOOP load sequencer.
- If the voltage is not restored to the affected bus after closing the incoming circuit breaker from the UAT, the incoming circuit breaker from UAT is opened by the undervoltage signal. This condition is equivalent to LOOP condition for the affected Class 1E buses.
- During LOOP condition, the incoming circuit breaker from the UAT and RAT are tripped. The incoming circuit breaker from the Class 1E GTG associated with the affected Class 1E bus is closed after the Class 1E GTG reaches set voltage and frequency.
- Loads required for LOOP condition are started in sequence by the LOOP load sequencer.

If the Class 1E GTG is operating in parallel with the offsite power source from RAT, during periodic testing and loss of offsite power from RAT occurs due to the tripping of incoming circuit breaker from RAT by the protections, then the automatic fast bus transfer from RAT to UAT is blocked. The Class 1E GTG continues to power the loads running on the bus prior to the tripping of incoming breaker from RAT.

B. Automatic transfer of Class 1E buses from RAT to UAT initiated by loss of offsite power from RAT

The bus undervoltage signal initiates slow transfer as shown below:

- The bus undervoltage signal trips the incoming circuit breaker from RAT and starts the Class 1E GTGs associated with the affected buses.
- Trip the motor loads on the affected buses.
- Incoming circuit breaker from the UAT is closed after 1 second, if incoming circuit breaker from RAT is open and the 6.9kV bus protection relay has not operated. If the voltage to the affected Class 1E buses is restored from the alternate offsite power from UAT, loads on the affected bus are started by the LOOP load sequencer.
- If the voltage is not restored to the affected bus after closing the incoming circuit breaker from the UAT, the incoming circuit breaker from UAT is opened by the undervoltage signal. This is equivalent to LOOP condition for the affected Class 1E bus.

- During LOOP condition, the incoming circuit breaker from the Class 1E GTG associated with the affected Class 1E bus is closed after the Class 1E GTG reaches set voltage and frequency.

- Loads required for LOOP condition are started in sequence by the LOOP load sequencer.

If the Class 1E GTG is operating in parallel with the offsite power source from RAT during periodic testing and a loss of offsite power from RAT occurs, then the following scenario develops:

- Incoming circuit breakers from the RAT and Class 1E GTG remain closed and the Class 1E GTG continues to power the loads connected to the bus prior to the loss of offsite power from the RAT.

- Since the incoming circuit breaker from RAT is still closed, the Class 1E GTG gets overloaded and the frequency at the Class 1E bus drops. (The automatic voltage regulator of the Class 1E GTG may maintain the voltage.)

- The bus underfrequency relay initiates tripping the incoming circuit breaker from the Class 1E GTG instead of undervoltage relay to prevent the Class 1E GTG from damage. The GTG can continue to run.

- After tripping the incoming circuit breaker from the Class 1E GTG, the motor loads on the bus and the incoming circuit breaker from the RAT are tripped by the bus undervoltage signal.

- Power to the affected bus is restored either from the UAT or the GTG by the slow transfer and the loads required during LOOP are started in sequence by the LOOP load sequencer.

C. LOCA with offsite power available

In case of LOCA, the GLBS is opened, power from RAT to the Class 1E buses A, B, C and D is not affected. The Class 1E GTGs are started by emergency core cooling system (ECCS) actuation signal. The loads on the Class 1E buses A, B, C and D do not get tripped and additional accident loads are automatically started by the ECCS load sequencer. The Class 1E GTGs start by the ECCS actuation signal and run with no load. If the Class 1E GTG is operating in parallel with the offsite power source prior to LOCA, the ECCS actuation signal opens the Class 1E GTG circuit breaker. GTG continues to run with no load. The loads on the Class 1E buses A, B, C and D do not get tripped and additional accident loads are automatically started by the ECCS load sequencer. The Class 1E GTGs are stopped manually.

D. Automatic transfer of Class 1E buses from RAT to UAT due to loss of offsite power from RAT and LOCA occurring simultaneously

The Class 1E GTGs are automatically started by the ECCS actuation signal. Loss of offsite power from the RAT is sensed by the Class 1E bus undervoltage relays and the motor loads on the affected bus are tripped. The undervoltage relays trip the incoming circuit breaker from RAT. The incoming circuit breaker from UAT is closed after one second if the following conditions are satisfied:

- The incoming circuit breaker from the RAT is open.
- The MT circuit breaker is closed or GLBS is closed which means offsite power from UAT is available.
- Class 1E 6.9kV bus protection relay has not operated.

After the incoming circuit breaker from the UAT is closed, the accident loads are started by the ECCS load sequencer. If the transfer to UAT fails, the UAT breaker is tripped by the bus undervoltage signal and the incoming circuit breaker from the Class 1E GTG is closed after the Class 1E GTG reaches set voltage and frequency. The accident loads are started by the ECCS load sequencer.

When the offsite power becomes available from UAT or RAT, the Class 1E buses can be transferred to the offsite source as follows:

1. The Class 1E GTG is synchronized with the offsite source.
2. Incoming circuit breaker from the offsite source is closed.
3. The Class 1E GTG is unloaded and the circuit breaker from the Class 1E GTG is opened.
4. Class 1E GTG is stopped.

E. Manual transfer of Class 1E buses to non-Class 1E AAC GTG during SBO condition

LOOP combined with failure of onsite Class 1E GTGs to restore power to the Class 1E ac buses results in SBO condition. Power to one Class 1E 6.9kV bus can be restored manually from the AAC GTG as follows:

1. 6.9kV permanent bus P1 and P2 undervoltage relays operated by LOOP give signal to the A-AAC GTG and B-AAC GTG to start automatically.
2. As soon as the AAC GTGs reach the set voltage and frequency limits, AAC GTG circuit breaker in the selector circuit closes automatically.
3. As soon as the AAC GTG circuit breaker in selector circuit A closes, A-AAC GTG gets connected to 6.9kV permanent bus P1. Loads on 6.9kV permanent bus P1 are automatically started in sequence as shown in Figure 8.3.1-2. During an SBO, power to one of the Class 1E 6.9kV buses A or B can be restored manually at operator discretion from the A-AAC GTG by closing the tie connection between A-AAC GTG and the Class 1E 6.9kV bus A or B by local manual closing of the circuit breaker in the selector circuit A and the A-AAC GTG incoming circuit breaker in the Class 1E switchgear A or B. Those loads that are not required to

be running during an SBO on the permanent bus P1, are tripped manually by de-energizing of P1 bus. The loads required on the Class 1E buses A (or B) are manually started.

4. Similarly, as soon as the B-AAC GTG circuit breaker in selector circuit B closes, B-AAC GTG gets connected to 6.9kV permanent bus P2. Loads on 6.9kV permanent bus P2 are automatically started in sequence as shown in Figure 8.3.1-2. Power to one of the Class 1E 6.9kV buses C or D can be restored manually from the B-AAC GTG by closing the tie connection between B-AAC GTG and the Class 1E 6.9kV bus C or D by local manual closing of the circuit breaker in the selector circuit B and the B-AAC GTG incoming circuit breaker in the Class 1E switchgear C or D. Those loads that are not required to be running during an SBO on the permanent bus P2, are tripped manually by de-energizing of P2 bus. The loads required on the Class 1E buses C (or D) are manually started.

Restoration of power to only one Class 1E 6.9kV bus is required to cope with an SBO. A detailed description of the restoration of electrical power to the Class 1E buses from the AAC GTGs during an SBO is included Section 8.4.

8.3.1.1.2.5 Protection of Class 1E AC Onsite Power System

Protection mechanisms for the Class 1E power system equipment and components are designed meet the criteria provided in IEEE Std 741 (Reference 8.3.1-7). Some of the important protection mechanisms are as shown in Figure 8.3.1-1 and described below:

<u>Protections for Class 1E systems</u>

Undervoltage protection

Each Class 1E 6.9kV bus is provided with undervoltage relays for (1) protecting the Class 1E loads from prolonged undervoltage during degraded grid conditions (2) starting the emergency Class 1E GTGs (3) tripping the motor feeder breakers (4) tripping and closing the incoming breakers and (5) initiating undervoltage alarms.

Two sets of undervoltage relays are provided on each Class 1E 6.9kV bus, one set to detect loss of bus voltage and the other to detect the degraded voltage conditions.

Loss of bus voltage protection

The Class 1E 6.9kV bus undervoltage relay initiates loss of bus voltage signal by using two out of three logic. The undervoltage relays are set to actuate if the bus voltage drops below 70% for more than set time delay. This voltage setting prevents relay operation during large motor starting. The time delay is selected long enough to prevent actuation of loss voltage signal during some electrical faults when the bus voltage could drop below 70% for a few cycles before the fault is cleared.

The loss of bus voltage signal initiates:

- Tripping of incoming circuit breaker from the RAT.
- Tripping of motor feeder circuit breakers.
- Starting emergency Class 1E GTG.
- Closing of the incoming circuit breaker from the UAT or Class 1E GTG, by slow transfer.

Degraded voltage protection

In addition to the undervoltage relays provided to detect LOOP at the Class 1E buses, a second level of undervoltage protection with time delay is provided on each 6.9kV Class 1E bus to protect the Class 1E equipment from prolonged undervoltage in accordance with BTP 8-6 (Reference 8.3.1-8). The voltage sensors and the relays are separate and independent for each train.

The degraded voltage and time delay setpoints are selected based on the voltage requirements of the Class 1E loads at all voltage levels. The degraded voltage relays are set to provide a Class 1E load terminal voltage of greater or equal 90% of load rated voltage.

Degraded voltage condition is detected by using two out of three logic. Two separate time delays are provided for detecting the degraded voltage conditions:

- The first time delay is set long enough to prevent operation during undervoltage conditions due to motor starting transients. Following this time delay, an alarm is initiated in the MCR. Subsequent to this time delay, if a LOCA occurs, the Class 1E distribution system is isolated from the offsite power system.
- The second time delay is set to prevent damage to permanently connected Class 1E loads. Following this time delay, the following actions are taken to isolate the Class 1E 6.9kV buses from the offsite power system:
    - Tripping of the incoming circuit breaker from the offsite power source
    - Starting the Class 1E GTG

The undervoltage relays can be tested and calibrated during power operation. Bypassing of these undervoltage relays is annunciated in the MCR.

The voltage levels at the Class 1E buses are optimized for the maximum and minimum load conditions and for the voltage variations of the offsite power sources.

Overcurrent protection

All incoming and outgoing switchgear circuit breakers are provided with multi-function relays. The protective functions are selected based on the load and circuit protection requirements. Overcurrent protection provided for major equipment is as follows:

- The time overcurrent protection is provided for all bus incoming circuit breakers.
- Motors and feeder cables are protected for short circuit, overload, ground fault and locked rotor conditions by long time and instantaneous overcurrent protections. Ground fault protection is provided by ground overcurrent relay with long time and instantaneous functions. The time over current relays are set in accordance with the recommendations provided in IEEE Std C37.96 (Reference 8.3.1-9). The instantaneous element is set high enough to override the asymmetrical inrush current.
- Protection on MV circuit breakers for load center feeders include overload, short circuit and ground fault protection with long time and instantaneous functions. The relay settings are based on the recommendations provided in IEEE Std C37.91 (Reference 8.3.1-10).
- The overcurrent protection is set to assure proper coordination throughout the electrical power distribution system.

Differential protection

Bus differential protection is provided for all MV buses. All incoming and outgoing breakers are tripped by actuation of this protection.

<u>480V load center protection</u>

Each 480V Class 1E load center bus is provided with undervoltage relays for tripping of feeder circuit breakers except for the MCCs and undervoltage annunciation.

Each 480V load center circuit breaker is equipped with a solid state protective device. Long-time, short-time, instantaneous and ground fault protection features are based on circuit protection requirements.

<u>480V motor control center protection</u>

Each 480V motor control center is equipped with molded case circuit breakers (MCCBs). MCCBs provide time over current and/or instantaneous short circuit protection for the connected loads. The MCCB for motor circuits has instantaneous trip only. Motor overload protection is provided by thermal trip units in the motor controller. The MCCBs for non-motor feeder circuits have thermal time over current protection and instantaneous short circuit protection.

<u>Motor operated valves</u>

The MCCs provide thermal overload protection to the motor operated valves in accordance with RG 1.106 (Reference 8.3.1-11). The thermal overload protection devices are continuously bypassed. Alarms are provided in the MCR. During normal control modes or manual testing, motor operated valves are protected by manual de-energizing based on thermal overload alarm.

8.3.1.1.2.6 Testing of AC Systems during Power Operation

All Class 1E circuit breakers and motor controllers are testable during reactor operation. During periodic testing of Class 1E system, subsystems of the engineered safety features actuation system, such as safety injection, containment spray, and containment isolation are actuated thereby causing appropriate circuit breaker or contactor operation. The 6.9kV and 480V switchgear circuit breakers and control circuits can also be tested independently while individual equipment is shutdown. These circuit breakers can be placed in test position and exercised without operation of the associated equipment. The use of jumpers or other temporary test arrangements which would bypass protective functions is not required to verify system capability to operate except during startup testing.

The testing of ac power systems is performed in accordance with IEEE Std 308, 338 and 603 (Reference 8.2-4) as endorsed by RG 1.32, 1.118 and 1.153 (Reference 8.3.1-19, 8.3.1-24 and 8.3.1-5). Bypassed and inoperable status indication is provided based on RG 1.47 (Reference 8.3.1-23) as described in Section 7.5.1.2. Surveillance testing of Class 1E ac power systems is described in detail in Chapter 16.

8.3.1.1.2.7 Sharing of Systems and Equipment between Units

The US-APWR is a single unit design, so there is no sharing of safety-related systems or components between units.

8.3.1.1.2.8 Class 1E Electrical Equipment Qualification

The electrical equipment identified as safety-related is qualified as Class 1E and is designated as seismic category I. The Class 1E equipment and components are capable of withstanding the environmental conditions to which they are exposed. The Class 1E equipment qualification meets the requirements of IEEE Std 323 (Reference 8.3.1-6), IEEE Std 344 (Reference 8.3.1-12) and applicable equipment standards.

8.3.1.1.3 Class 1E Standby Power Sources

GTG is used as Class 1E standby power sources for the US-APWR. Design of the Class 1E standby power sources for US-APWR is based on the use of qualified GTG for Class 1E applications based on the advantages shown below:

- The GTG is more reliable and has fewer components and auxiliary systems than diesel generators.

- The GTGs do not have cooling water requirements.

- The GTGs need less space than diesel generators.
- The GTGs require less maintenance than diesel generator units.

Note

The GTG starting time is within 100 seconds, compared to the 10 second starting time for a diesel generator. Based on the safety analysis of the US-APWR with an advanced accumulator, the required starting time for the emergency Class 1E standby source is 100 seconds. Therefore, the GTG starting time within 100 seconds is acceptable.

GTGs have rarely been used in the past in Class 1E standby power supply applications. The GTGs will be qualified for Class 1E application as standby emergency power sources using applicable regulations and standards, including ISO 3977-3 (Reference 8.3.1-44). The Class 1E qualification plan is presented in Technical Report MUAP-07024 (Reference 8.3.1-13). The result of qualification for Class 1E application as standby emergency power sources is described in Technical Report MUAP-10023 (Reference 8.3.1-43).

The plant has four redundant Class 1E trains, with identical safety-related equipment on all four trains. Each redundant Class 1E power supply train is provided with a dedicated and independent Class 1E GTG connected to the Class 1E 6.9kV bus in that train. The Class 1E GTG rating is shown in Table 8.3.1-1. Availability of power from any two Class 1E GTGs to the associated Class 1E trains is adequate to meet the maximum emergency load requirements during LOOP and LOOP+LOCA conditions. The Class 1E GTGs meet or exceed the requirements of RG 1.9 (Reference 8.1-2).

The Class 1E GTGs in each train are physically separated and electrically isolated from the Class 1E GTGs of the other trains. The Class 1E GTGs are housed in separate rooms of the PS/Bs, which are seismic category I structures, as shown in Figure 8.3.1-4. The power and control cables from the Class 1E GTGs A, B, C and D to their respective Class 1E 6.9kV buses are routed through physically separate routes from each other. This arrangement minimizes the potential for a common-cause failure such as missile, fire, flooding etc. affecting more than one redundant Class 1E GTG.

Rating of Class 1E GTGs is determined based on the characteristics of each connected load, required duration of operation and maximum combined load demand on the Class 1E GTG during the worst operating conditions. The loading for the Class 1E GTGs during various operating conditions is shown in Table 8.3.1-4. The maximum loading on the Class 1E GTG is determined based on the nameplate rating of the load, pump pressure and flow under runout conditions, or starting horsepower equivalent to motor brake horsepower. The ratings considered for each load are noted in the Figure 8.3.1-1 and Table 8.3.1-4. The inrush and other characteristics of the loads are presented in Technical Report MUAP-07024 (Reference 8.3.1-13).

The design aspects of the onsite Class 1E GTGs are discussed below:

8.3.1.1.3.1 Starting of GTGs

The Class 1E GTGs are started by the following methods:

- Automatic starting by the ECCS actuation signal
- Automatic starting by an undervoltage signal on the Class 1E 6.9kV bus to which the Class 1E GTG is connected
- Automatic starting by a degraded grid voltage signal on the Class 1E 6.9kV bus to which the Class 1E GTG is connected
- Manual starting from MCR
- Manual starting from the Class 1E GTG room in the PS/B.
- Manual starting from remote shutdown room in the R/B

The Class 1E GTGs start and are ready to accept load within 100 seconds after receiving the start signal. Restoration of power from the Class 1E GTGs to the Class 1E 6.9kV buses and automatic load sequencing is performed as follows:

- If the Class 1E GTGs are started automatically by the ECCS actuation signal without LOOP, then:
  1. The Class 1E GTGs start and run without being connected to the Class 1E buses.
  2. Required loads are automatically started on the buses as per the ECCS load sequence shown in Figure 8.3.1-2.
  3. Class 1E GTGs that are already started by the ECCS actuation signal are kept running with the Class 1E GTG breaker open. After this, Class 1E GTG will be stopped manually.
- If the Class 1E GTGs are started automatically by ECCS actuation signal coincident with LOOP or degraded grid voltage condition, then:
  1. The incoming circuit breakers from UAT and RAT offsite power supply connections to the Class 1E 6.9kV buses are tripped and are prevented from closing automatically.
  2. All the motor loads running on the affected Class 1E 6.9kV buses are tripped.
  3. Class 1E GTGs that are already started by the ECCS actuation signal are automatically connected to their associated Class 1E buses.
  4. Required loads are automatically started on the bus as per the ECCS load sequence shown in Figure 8.3.1-2.

- If the Class 1E GTGs are started by an undervoltage signal or a degraded grid voltage signal (without the ECCS actuation signal), then:

  1. Motor loads connected to the Class 1E buses are tripped by the undervoltage signal.
  2. Class 1E GTG associated with the Class 1E bus is started.
  3. Incoming circuit breakers from the UAT and RAT offsite power supply connections to the Class 1E 6.9kV bus are tripped and prevented from reclosing automatically.
  4. The Class 1E GTGs that are already started are automatically connected to the Class 1E buses.
  5. The loads on the Class 1E buses are automatically started and connected to the Class 1E buses per the LOOP load sequence shown in Figure 8.3.1-2. Should a LOCA occur during the LOOP load sequencing or after completing the LOOP load sequence, the loads required by ECCS actuation signal are started as per the ECCS load sequence with shedding of the loads that are not required.

The Class 1E GTGs are also manually started and paralleled with the offsite power supplies during periodic load testing of the Class 1E GTGs.

The automatic starting of Class 1E GTG, circuit breaker closing and load sequencing logic diagrams are shown in Figure 8.3.1-2. The manual and automatic switching of the incoming circuit breakers from the offsite sources, Class 1E GTGs, and load sequencing operations are also covered in Subsection 8.3.1.1.2.4.

The voltage and frequency variations during Class 1E GTG load sequencing and recovery to within acceptable limits meet or exceed the criteria established in RG 1.9 (Reference 8.1-2).

8.3.1.1.3.2 Class 1E GTG Starting System

The starting system for the Class 1E GTGs is a compressed air system. The starting system for each Class 1E GTG is independent and physically separate. Refer to Subsection 9.5.6 for a detailed description of starting system.

8.3.1.1.3.3 Tripping Devices

The following trip protective functions are provided during operation of the Class 1E GTG:

1. Overspeed
2. Generator differential current
3. High exhaust gas temperature

4. Failed to start

5. Overcurrent

6. Low pressure lube oil

7. High temperature lube oil

8. Anti motoring

During operation of the Class 1E GTG under a LOCA condition, all protective functions are bypassed except the functions listed below and a Class 1E GTG trouble alarm is initiated in the MCR:

1. Overspeed

2. Generator differential current

3. High exhaust gas temperature

The Class 1E GTGs are monitored from the MCR and each device, when actuated, initiates annunciation in the MCR. These functions are also provided with alarms in the Class 1E GTG room. The alarms, where possible, are set so that they provide a warning of impending trouble prior to tripping the Class 1E GTGs.

8.3.1.1.3.4 Interlocks

Each Class 1E 6.9kV bus is provided with connections to two offsite power supplies, one Class 1E GTG and one non-Class 1E AAC GTG. Class 1E incoming circuit breakers in the Class 1E 6.9kV switchgear provide isolation between the power sources and the Class 1E 6.9kV buses. Only one incoming breaker is closed at any time except during testing of the Class 1E GTG in parallel with offsite sources or for a short duration during parallel transfer from one source to an other during restoration of power to the Class 1E buses from the offsite power supplies, AAC GTGs after SBO. The following interlocks are provided for automatic and manual closing of the incoming breakers:

- The incoming breaker to the Class 1E 6.9kV bus cannot be closed on to a faulted bus during bus transfer.

- Only one incoming circuit breaker to the 6.9kV bus is closed during all modes of operation except during parallel operation of the Class 1E GTG with offsite power source during periodic testing or for a short duration during parallel transfer from the AAC GTG.

- During manual transfer of power from UAT to RAT or RAT to UAT, both the incoming circuit breakers from UAT and RAT are momentarily paralleled after synchronizing both the sources. Electrical interlocks are provided to prevent both incoming breakers from the offsite sources remaining paralleled.

- During periodic testing, the Class 1E GTG is operated in parallel with the offsite power source. The incoming breaker from the GTG is interlocked to close only after synchronization with the offsite power source.

- During LOOP, bus undervoltage signal trips both incoming circuit breakers on the bus connected to the offsite sources and prevents them from automatic re-closing.

- When the Class 1E GTG provides power to the 6.9kV buses, the incoming breaker from the offsite power supply can only be closed manually after synchronizing the offsite power source with the Class 1E GTG supplying power to the bus. The incoming breaker from the Class 1E GTG is tripped manually after the incoming breaker from the offsite power source is closed.

- The tie connection between the Class 1E 6.9kV buses A, B, C & D and the non-Class 1E AAC GTGs is normally open. The tie can only be closed manually by administrative controls and automatic closing interlocks are not provided.

8.3.1.1.3.5 Permissive

A switch is provided in the Class 1E GTG room in the PS/B for each Class 1E GTG to block automatic start signals when the Class 1E GTG is out for maintenance. When the switch is in local position, annunciation is initiated in the MCR.

The Class 1E GTG can be started from the Class 1E GTG room, the MCR or the remote shutdown room.

The manual start switch provided in the Class 1E GTG room bypasses the automatic start signals to allow a manual start of the Class 1E GTG. During periodic tests, a test switch in the MCR allows parallel operation with the offsite source after starting and synchronization of the Class 1E GTG.

8.3.1.1.3.6 Load Shedding and Sequencing Circuits

The bus undervoltage signal due to loss of voltage or degraded grid voltage on the Class 1E 6.9kV buses initiates the following actions:

- Shed all motor loads by loss of voltage signal.

- Send a signal to start the Class 1E GTG associated with the affected Class 1E bus.

- Trip the incoming breakers from the offsite power supplies through UAT and/or RAT and prevent them from reclosing.

Each Class 1E GTG is designed to start, reach set voltage and frequency and be ready to accept loads within 100 seconds after receipt of a start signal. All the automatically sequenced loads are connected to the Class 1E bus in 50 seconds after connecting Class 1E GTG to the Class 1E bus as shown in Figure 8.3.1-2. The Class 1E GTG terminal voltage and frequency are measured by the relays at the Class 1E GTG terminals and provide a permissive interlock for the closing of the respective Class 1E GTG circuit breaker. After connecting the Class 1E GTG to the bus, the loads on the Class 1E bus are connected automatically in sequence at programmed intervals as shown in Figure 8.3.1-2.

Should a LOCA occur during the LOOP load sequencing or after the LOOP sequencing is completed, the ECCS actuation signal initiates the ECCS load sequence. The loads that are not needed by the ECCS except MCC loads are shed by the ECCS actuation signal.

If a LOOP occurs during ECCS load sequencing or after ECCS load sequencing is completed, the ECCS load sequencing is reset and all motor loads are shed by the undervoltage signal.

If power to the bus is restored either from the UAT or Class 1E GTG after slow transfer, the ECCS load sequence is restarted. Loads operated for the LOCA sequence are shown in Figure 8.3.1-2.

8.3.1.1.3.7 Loss of Class 1E GTG

Should a Class 1E GTG fail due to a mechanical or electrical malfunction or is tripped by one of the trip signals, as shown in Subsection 8.3.1.1.3.3, the sequencer will shed all loads after the Class 1E GTG breaker has opened.

8.3.1.1.3.8 Testing

The following site tests are performed on the Class 1E GTG during the plant preoperational test program and during the plant operation. The test procedures include a final equipment check prior to starting the tests.

1. During the plant preoperational test programs only, 25 consecutive start tests for each Class 1E GTG are to be run with no failures, to demonstrate the required reliability.

2. During the plant operation, a single start test on 31 day test intervals will be performed. The periodic testing of Class 1E GTG during the plant operation is intended to:

   a. Demonstrate that the Class 1E GTG starts and verify that the required voltage and frequency are attained.

   b. Demonstrate load-carrying capability, with load equivalent to 90 – 100 % of the continuous rating of the Class 1E GTG, for an interval of not less than 1 hour.

      This test may be accomplished by synchronizing the Class 1E GTG with the offsite power system from either a RAT or the UAT, and loading at the maximum practical rate as recommended by manufacturer. Testing may be performed at a power factor of 0.8 within the class 1E GTG capability.

3. GTG failures will be addressed in accordance with plant procedures that implement the provisions of 10 CFR 50.65 (Reference 8.2-7).

4. The Technical Specifications will include requirements such that during the preoperational period and at least once every 24 months after the plant is in operation, tests are run during shutdown (except for tests described by items f, g, h, and k). The test procedures include a final equipment check prior to starting the tests. Tests described by items e, f, g and i may be performed during any mode of plant operation, as required.

   a. Demonstrate that on loss of offsite power the Class 1E buses are de-energized and that the loads are shed from the Class 1E buses in accordance with design requirements.

   b. Demonstrate that on loss of offsite power the Class 1E GTGs start on the auto start signal, load shed occurs, the Class 1E buses are energized along with SSTs, the auto connected shutdown loads are energized through the load sequencer, and the system operates for 5 minutes while the Class 1E buses are loaded with the shutdown loads.

   c. Demonstrate that on an engineered safety features actuation signal (without loss of offsite power) the Class 1E GTGs start on the auto start signal and operate on standby for 5 minutes.

   d. Demonstrate that on loss of offsite power, in conjunction with an engineered safety features actuation signal, the Class 1E GTGs start on the auto start signal, load shedding occurs, the emergency buses are energized along with SSTs, the auto connected emergency (accident) loads are energized through the load sequencer, and the system operates for 5 minutes while the Class 1E GTGs are loaded with the emergency loads.

   e. Demonstrate load-carrying capability for 24 hours, of which 22 hours are at a load equivalent to 90 – 100 % of the continuous rating of the Class 1E GTG and 2 hours at a load equivalent to 110 % of the continuous rating of the Class 1E GTG.

   f. Demonstrate functional capability at full load temperature conditions by verifying the Class 1E GTG starts upon receipt of a manual or auto-start signal, and the generator voltage and frequency are attained within the required time limits.

   g. Demonstrate proper operation during Class 1E GTG load shedding, including a test of the loss of the largest single load and of complete loss of load. Verify that the overspeed limit is not exceeded.

   h. Demonstrate the ability to:

      - Synchronize the Class 1E GTG unit with the offsite system while the unit is connected to the emergency load.

- Transfer the emergency load to the offsite system.
- Restore the Class 1E GTG to standby status.

i. Demonstrate that the fuel transfer pumps transfer fuel from each fuel storage tank to the day tank of each Class 1E GTG.

j. Demonstrate that, with the Class 1E GTG operating in a test mode and connected to its Class 1E bus, a simulated ECCS signal overrides the test mode by: (1) returning the GTG to standby operation, and (2) automatically energizing the emergency loads with offsite power.

k. Demonstrate that the specified automatic trip signals for the GTG are bypassed automatically as designed.

l. Demonstrate that by starting and running (unloaded) redundant units simultaneously, common failure modes that may be undetected with single GTG testing do not occur.

The test procedures will specifically state that the Class 1E GTG unit is to be reset at the conclusion of the test to allow an automatic start when required.

8.3.1.1.3.9 Maintenance

Maintenance should be performed in accordance with the requirements of GTG engine manufacturer. Of particular importance is cleaning of the fuel nozzle. The fuel nozzle should be cleaned in accordance with the manufacturer's recommendations. A GTG engine maintenance plan will be established.

8.3.1.1.3.10 Fuel Oil Storage and Transfer Systems

Each Class 1E GTG is provided with dedicated and independent fuel oil supply system, fuel oil day tank and storage tank. The fuel oil systems are not shared between the GTGs of redundant groups and these systems are designed to minimize common cause failure between the GTGs of redundant groups.

The day tank capacity is adequate for 1.5 hours of operation Class 1E GTG at maximum required loading.

The maximum expected loading for Class 1E GTG occurs under LOOP+LOCA conditions. The electrical power and control circuit power supplies for the Class 1E fuel oil system are provided from the Class 1E power systems in the same train.

The day tank is located inside the associated Class 1E GTG room in the PS/B. The fuel level in the day tank is maintained automatically by the fuel transfer pumps pumping the fuel from the storage tanks on day tank low level. Each day tank is provided with two fuel transfer pumps.

The storage tank capacity is adequate to meet the maximum load demand on the associated Class 1E GTG for 7 days. One independent and dedicated storage tank is provided for each Class 1E GTG. The storage tanks are located outside of the PS/B.

The Class 1E GTG fuel oil system is described in Subsection 9.5.4.

8.3.1.1.3.11 Cooling Water Systems

The GTG does not need cooling water system.

8.3.1.1.3.12 Instrumentation and Control Systems

Equipment is provided for the following operations:

- Manual starting and stopping.
- Manual and automatic synchronization.
- Manual frequency and voltage setting.
- Emergency stop in the Class 1E GTG room.
- Voltage regulator manually actuated droop and reset.

A selector switch is provided in each Class 1E GTG room for local/remote control selection. The switch is normally in the remote position, whereby the engineered safety features system senses an accident or loss of preferred power and starts the Class 1E GTG. The selector switch is placed in the local position to allow manual operation of the Class 1E GTG locally when it is out for maintenance. Then the local manual start switch functions to start the Class 1E GTG. Equipment is also provided locally at remote shutdown room for each Class 1E GTG manual starting in case of a MCR evacuation.

The local control operation is annunciated in the MCR. The power source for the Class 1E GTG instrumentation and control system is in the same load group as the respective Class 1E GTG.

Each Class 1E GTG local control panel is equipped with the alarms listed in Table 8.3.1-8. Most of the alarms are duplicated in the MCR.

Electrical instruments are provided in the MCR for surveillance of generator voltage, current, frequency, power, and reactive volt amperes and also at the Class 1E GTG for surveillance of Class 1E GTG voltage, current, and frequency. The status of each Class 1E 6.9kV breaker of the engineered safety features system is displayed on the operator console in the MCR. Local indication is also provided at the switchgear.

Each Class 1E GTG system status can be monitored on the operator console in the MCR.

For the Class 1E GTG to be automatically or manually started from MCR or remote shutdown room, the mode switch on the Class 1E GTG control panel must be in the "Remote" position of control (local/remote) switch on the Class 1E GTG control panel. If the switch is not in remote position, an alarm on the operator console in the MCR and Class 1E GTG control panel will alert the operator that the Class 1E GTG is disabled.

8.3.1.1.4 Control Rod Power Supply

Electric power to control rod drive mechanism (CRDM) is supplied by two full capacity motor-generator sets. Each motor-generator set is powered from separate non-Class 1E 480V buses N3 and N5.

Each generator is driven by a 132kW (≈177HP) induction motor. The ac power is distributed to the rod control power cabinets through two Class 1E series connected reactor trip breaker sets each of which is located in the separate fire area.

8.3.1.1.5 Class 1E 480V AC Inverter Supply to MOVs

The Class 1E ac motor operated valves MCCs requiring Class 1E uninterrupted 480V ac power supply are fed from the 60kVA, 480V ac, 3 phase, 60Hz inverter. There are six inverters: Two each on train A and train D and one on each Class 1E train B and C. The inverter is connected to the Class 1E 125V dc bus in each train, as shown in Figure 8.1-1. The A MOV MCC1, A MOV MCC2, B MOV MCC, C MOV MCC, D MOV MCC1 and D MOV MCC2 are normally fed from the corresponding train of the MOV inverter each of which is backed up by the pertinent Class 1E 125V dc bus as shown in Figure 8.1-1. The Class 1E ac MCC backups the associated train MOV MCC in case of loss of MOV inverter output.

In the event of a postulated LOCA and coincident LOOP, the battery charger input power to the MOV inverters may be lost for up to 100 seconds until the onsite Class 1E GTGs are ready to accept loads. Each MOV is started at the required time by automatic starting signal for equalization of dc current. The 125V dc batteries and the MOV inverters are sized for continuous operating load and coincident starting load of all MOVs actuated by an engineered safety features actuation signal. The MOVs that are required to operate by an engineered safety features actuation signal and their load currents are shown in Table 8.3.1-10.

8.3.1.1.6 Class 1E 120V AC I&C Power Supply

There are four independent Class 1E 120V ac I&C power supply trains A, B, C & D to supply four trains of the protection and reactor control systems, as shown in Figure 8.3.1-3.

Each train consists of a UPS unit and three panelboards. UPS units contain a main inverter circuit, a bypass transformer circuit, and a static transfer switch for switching of main output from the inverter to the bypass transformer. Input to the main inverter and the bypass transformers in each train is obtained from the ac and dc buses belonging to the same train. The main inverter output circuit for the UPS of each train connects to two panelboards of the same train. The bypass transformer circuit connects to a single panelboard of the same train. Also, the main inverter output circuit for each train can be manually connected to a panelboard of an alternate train (A and B, or C and D) during GTG online maintenance condition as shown in Figure 8.3.1-3. Nominal ratings of major Class 1EI&C equipment are shown in Table 8.3.1-11.

In each UPS unit, when the inverter fails or is out on maintenance, the 120V ac bus is transferred to the bypass transformer by static switch or manually through synchronizing, without interruption of power to the loads. The static switch has the capability of automatically retransferring the load back to the inverter after its output has returned to normal.

During LOOP input to the UPS unit is powered by the Class 1E battery and the supply to the 120V ac distribution panel is restored without interruption.

Output voltage and current of UPS and transformer are displayed in the MCR. Position of switching circuit and voltage of buses are also displayed in the MCR.

Protection of UPS is provided in accordance with IEEE-446 and recommendation from manufacturers. 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.

8.3.1.1.7 Non-Class 1E 120V AC I&C Power Supply

The non-Class 1E 120V ac I&C power supply is designed to furnish reliable power to non safety-related plant instruments and controls. There are nine non-Class 1E 120V ac I&C power supply systems as shown in Figure 8.3.1-3. Each system consists of a UPS unit with an inverter and a bypass transformer, bypass switches and 120V ac distribution panels. The ac input to the inverter and the bypass transformer is provided from different MCCs connected to 480V ac permanent buses P1 and P2. This arrangement results in the availability of ac power to the inverters from either of the permanent buses P1 or P2.

Each UPS and bypass transformer is connected to the 120V ac distribution panel. Each bypass transformer is connected to the 120V ac bus via switching circuit when the inverter in not in service.

Normally the 120V ac bus is fed from the inverter. When the inverter fails or is out on maintenance, the 120V ac bus is transferred to the bypass transformer by static switch or manually through synchronizing, without interruption of power to the loads.

When a LOOP occurs, the inverter is fed from the battery for the time required for the non-Class 1E I&C loads that include AAC GTG control to start and begin accepting load. The ac input power to the inverter and/or the bypass transformer will be automatically restored.

The non-Class 1E UPS systems are rated for 120V ac, 1 phase, 60kVA.

8.3.1.1.8 Electrical Equipment Layout

The locations of Class 1E equipment are selected to minimize vulnerability to physical damage. Wherever practicable, electrical equipment is located away from mechanical piping in order to minimize the damaging effects of pipe ruptures. The degree of separation takes into account the potential hazards in a particular area. Separation is achieved by locating equipment and circuits in separate rooms, maintaining distance, or by use of barriers. The potential hazard of non safety-related equipment failure on safety-related redundant equipment is considered in the choice of equipment location or protection.

Class 1E switchgear and equipment located below the probable maximum flood level are protected as described in Section 3.4.

The following are the general features of the electrical equipment layout:

Major Class 1E equipment locations are shown in Figure 8.3.1-4 and Table 8.3.1-9 and described below:

- Class 1E switchgears, load centers and motor control centers of redundant trains A, B, C and D are located in separate rooms in the R/B.

- Class 1E batteries, battery chargers and dc switchboards of train A, B, C and D are located in separate rooms in the PS/B. Battery room ventilation considerations are addressed in Subsection 9.4.5.

- 120V ac distribution panels and dc panelboards for trains A, B, C and D are located in separate rooms of R/B.

- Class 1E GTGs A, B, C and D, and their auxiliaries are located in separate rooms of PS/B.

- Four separate and independent cable routes are provided for the four Class 1E trains A, B, C and D. The load center A1 is considered part of train A and the cables from the load center A1 are routed along with the train A cables. The load center D1 is considered part of train D and the cables from the load center D1 are routed along with the train D cables.

- Piping containing fluids is excluded from the Class 1E electrical distribution equipment rooms. Class 1E electrical distribution equipment rooms of different trains are separated from each other by walls and by floor elevations with concrete floors. Any electrical or physical failure in one room has no effect on the redundant equipment in the other rooms.

The Class 1E equipment and the cable routing for each train is uniquely identified by the equipment tag numbering system and the following color code:

  - Train A : Red
  - Train B : Green
  - Train C : Blue
  - Train D : Yellow

- Each cable is color coded at a maximum interval of 5 feet along the length of the cable.

- Each raceway is color coded at a maximum interval of 15 feet along the length of the raceway.
- Safety-related cable trays of different trains are located in different fire areas except in the MCR complex and in the containment vessel (C/V).

Major non-Class 1E equipment locations are shown in Table 8.3.1-9 and are described below:

- UATs and RATs are located outdoors, physically separated from each other as shown on Figure 8.2-1.
- Non-Class 1E 13.8kV and 6.9kV switchgears and 480V load centers N1, N2, N3, N4, N5, N6, P11, P12, P21 and P22 are located separately in two T/B electrical rooms.
- Non-Class 1E MCCs P12, P22, N1, N2, N32, N42, N52 and N62 are located separately in T/B area local. Non-Class 1E MCCs P11, P21, N31, N41, N51 and N61 are located in the auxiliary building (A/B).
- Non-Class 1E batteries N1 and N2 are located in A/B. Non-Class 1E batteries N3 and N4 are located separately in two T/B electrical rooms.
- Non-Class 1E UPS units and 120V ac buses N11, N12, N31, N32, N41, N42 and N5; battery chargers N1, N2 and N12, and 125V dc buses N1 and N2 are located in the A/B.
- Non-Class 1E UPS units and 120V ac buses N21 and N22; battery chargers N3, N4 and N34, 125V dc buses N3 and N4 are located in T/B electrical room.

8.3.1.1.9 Design Criteria for Class 1E Equipment

Design criteria for the Class 1E equipment are discussed below.

Motor size

The nameplate horsepower rating of the motor is selected to equal or exceed the maximum horsepower required by the driven load under normal running or runout conditions.

Class 1E motors larger than 300HP are connected to the 6.9kV Class 1E buses. Class 1E motors up to 300HP are connected to the 480V Class 1E load center buses.

Minimum motor accelerating voltage

All Class 1E motors required to be started when GTG is supplying the 6.9kV and 480V Class 1E buses during LOOP condition are specified with accelerating capability to accelerate to full speed at 80% of nameplate voltage for a 6.6kV motor, and at 75% of nameplate voltage for a 460V motor. The voltage drop calculations show that the minimum voltage at the motor terminals during starting is above 80% of nameplate rating for a 6.6kV motor, and at 75% for a 460V motor. The electrical system is designed so that the terminal voltage at each Class 1E motor will permit acceleration of that motor in the required time.

Motor starting torque

The motor starting torque is adequate for starting and accelerating the connected load to normal speed within sufficient time to perform its safety function for all expected operating conditions, including design minimum bus voltages stated in Table 8.3.1-2. Motor acceleration time is specified to achieve motor rated speed in accordance with the loading sequence established in Figure 8.3.1-2.

Minimum torque margin over pump torque through the accelerating period is such that the pump motor assembly reaches nominal speed within sufficient time to perform its safety function at the design minimum terminal voltage.

Motor insulation

Insulation systems are selected based on the particular ambient conditions to which the insulation is exposed. For Class 1E motors located within the containment, the insulation system is selected to withstand the postulated accident environment.

Temperature devices provided in large horsepower motors

Each motor in excess of 1075kW (≈1500HP) is provided with six resistance temperature detectors (RTD) embedded in the motor slots, two per phase. During normal operations, the RTD at the hottest location monitors the insulation temperature and provides a motor high temperature alarm in the MCR. Motors on the 6.9kV system are provided with a thermocouple to provide a bearing high temperature alarm in the MCR.

Interrupting capacities

The interrupting capacities of the protective equipment are determined as follows:

Interrupting capacities of switchgear, load centers, MCCs and distribution panels are selected to be greater than the maximum calculated short circuit current at the point of application. The magnitude of the short circuit currents is calculated based on applicable ANSI and IEEE standards. Short circuit contributions from the offsite power system, single GTG operating in parallel and running motor contributions are considered simultaneously in determining the short circuit current at any location. Transformer impedances are selected to limit the short circuit currents within the interrupting and momentary capabilities of the breakers while at the same time permitting starting of the biggest motor on the bus without exceeding the voltage variations at the motor terminals shown in Table 8.3.1-2. Short circuit analysis is to be provided by the COL Applicant.

Electric circuit protection

Electric circuit protection is provided to prevent damage to the equipment, maintain operational continuity, and reduce the safety hazard to the plant personnel. Electric circuit protections are described in Subsection 8.3.1.1.2.5.

Class 1E cables

Safety-related cables are qualified for the design life of the plant as described in the latest IEEE Std 323 (Reference 8.3.1-6) and IEEE Std 383 (Reference 8.3.1-14) standards.

Cable and raceway separation criteria:

Cables of different voltage levels are installed in separate raceways. The voltage level division are as follows:

- Medium voltage power (6.9 kV)
- Low voltage power (e.g., 480 V)
- Control (e.g., 120V/125V)
- Instrumentation

Where trays are stacked, the order from top to bottom is as shown above.

Cables of each train are run in separate raceways and are physically separated from cables of the other trains. Separation of different trains is in accordance with IEEE Std 384 (Reference 8.3.1-1), as endorsed by RG 1.75 (Reference 8.3.1-2). Raceways for non-Class 1E are separated from each Class 1E, train A, B, C and D. Raceways for non-Class 1E are routed in the same areas as raceways of Class 1E while maintaining separation in accordance with IEEE Std 384 (Reference 8.3.1-1), as endorsed by RG 1.75 (Reference 8.3.1-2).

Cable conductor size selection and cable fill:

Cable conductor size selection for medium-voltage power, and low-voltage power and control cables are based on cable ampacity and voltage drop considerations. In addition, the conductor of all medium-voltage power cables and low-voltage power cables are sized to withstand the maximum available fault current. In general, cable ampacities are based on maximum cable ambient temperature, rated cable insulation temperature of 90ºC, and the cables' routing mode. IEEE Std 835 (Reference 8.3.1-30) and ICEA P-54-440/NEMA WC-51 (Reference 8.3.1-31) are used for cable conductor size selections.

Medium-voltage power cables are routed in ladder type trays in a single layer, the sum of all cable diameters not exceeding 90 percent of tray internal width. The allowable tray fill for low-voltage power and control cables are 30 percent and 40 percent of tray cross-sectional area, respectively. Solid-bottom and solid-cover type cable trays are used in routing instrumentation cables, with an allowable fill of 40 percent of tray cross-sectional area. When cables are routed in conduit, the allowable fill is per Table 1 in Chapter 9 of NFPA 70 (Reference 8.3.1-32). The COL Applicant is to describe a testing methodology and cable monitoring program for underground and inaccessible cables within the scope of the maintenance rule (10 CFR 50.65).

8.3.1.1.10 Heat Tracing

The chemical and volume control system and primary liquid and gaseous sampling system are provided with heat tracing systems. A heat tracing system provides non-Class 1E electrical heating where required temperature needs to be maintained.

The heat tracing system is powered from a permanent bus which is backed by the AAC GTG.

8.3.1.1.11 Grounding and Lightning Protection System

The grounding and lightning protection system consists of the following:

- Station ground grid
- System neutral grounding
- Equipment grounding
- I&C grounding
- Lightning protection

The design of the grounding system follows the procedures and recommended practices stated in IEEE Std 80, 81, 142, 524a and 665 (Reference 8.3.1-33, 34, 8.3.1-35 and 8.2-8).

The design of the lightning protection is in accordance with NFPA-780 (Reference 8.3.1-15). The lightning protection system is designed in accordance with the IEEE Std 665, 666, 1050 and C62.23 (Reference 8.2-8, 9 and 11) , as endorsed by RG 1.204 (Reference 8.3.1-16).

The station ground grid consists of buried, interconnected bare copper conductors and ground rods forming a plant ground grid matrix. The system maintains a uniform ground potential and limits the step-and-touch potentials to safe values under all fault conditions.

The system neutral grounding provides grounding of the neutral points of the MG, MT, UATs, RATs, SSTs, Class 1E GTGs and AAC GTGs. The neutrals of the MG, Class 1E GTGs and AAC GTGs are grounded through grounding transformers providing high-resistance grounding. The MT high voltage neutrals and SST low voltage neutrals are grounded solidly. The UAT and RAT low voltage winding neutrals will be resistance grounded.

The equipment grounding provides bonding of the equipment enclosures, raceways, metal structures, metallic tanks and ground bus of switchgears, load centers, MCCs, switchboards, panelboards and control cabinets to the station ground grid.

The I&C grounding provides isolated signal ground required by plant I&C systems. A separate radial grounding system consisting of isolated instrumentation ground buses and insulated cables is provided. The radial grounding systems are connected to the station ground grid at one point only and are insulated from all other grounding circuits.

Lightning protection for the plant is accomplished by providing a low-impedance path by which the lightning stroke discharge can enter the earth directly. The lightning protection system consists of air terminals, interconnecting cables, and downcomers to ground. The system is connected directly to the station ground to facilitate dissipation of the large current of a lightning stroke. The lightning arresters are connected directly to ground in order to provide a low-impedance path to ground for the surges caused or induced by lightning. Surge arrestors are provided to protect the MT, UATs, RATs, isolated phase busduct and the MV switchgear from lightning surges. Thus, fire or damage to the plant from a lightning strike is avoided.

The design of the ground grid and the lightning protection system is site-specific. Therefore, the design of both systems is the responsibility of the COL Applicant.

8.3.1.1.12 Electrical Equipment Subject to Submergence Due to Containment Flooding

Electrical equipment located in the C/V that would be subject to submergence under a LOCA condition includes miscellaneous non safety-related and safety-related equipment.

Equipment faults due to submergence would not cause damage to C/V electrical penetrations because the associated power circuits are either disconnected, are protected by redundant overcurrent protective devices, or have fault currents at the penetration below the penetration damage level.

The non safety-related devices are not designed for operation under water; however, there would be no effect on the safety-related power systems, since this equipment is powered from non safety-related buses.

8.3.1.1.13 Containment Vessel Electrical Penetrations

The electrical penetrations into the C/V comply with IEEE Std 317 (Reference 8.3.1-17).

Grouping of circuits in the C/V penetration is the same as raceway voltage groupings.

Modules for MV power (e.g., 6.9 kV) are in MV power penetrations; modules for low voltage power (e.g., 480 V) are in low voltage power penetrations; modules for control power (e.g., 120/125V) are in control power penetrations and modules for instrumentation signals are in instrumentation penetrations.

Electric penetrations of different Class 1E trains are separated by 3-hour rated fire barriers, separate rooms and/or locations on separate floor levels in R/B. Separation by distance without barriers is allowed only inside the C/V. Separation between the electrical penetrations of Class 1E trains and the electrical penetrations of non-Class 1E trains complies with IEEE Std 384 (Reference 8.3.1-1), as endorsed by RG 1.75 (Reference 8.3.1-2).

The penetrations are protected in accordance with IEEE Std 741 (Reference 8.3.1-7).

8.3.1.1.14 Control Circuit and Power

Plant instrumentation and control systems are described in detail in Chapter 7. Digital type control and protection devices are used for control and protection of generators, motors and electrical distribution equipment and circuits. The schematic logic diagrams for control and protection of major electrical distribution system equipment and circuits are shown in Figure 8.3.1-2. Digital control and protection systems are used for operation of electric motor loads of various plant process systems. Electric motor loads are powered from medium voltage switchgears, low voltage load centers, low voltage MCCs and low voltage dc switchboards. In general, the plant digital control systems provide the motor start stop control signals. The motor and motor circuit protections are provided by digital relays and solid-state protection devices. Typical motor control circuit schematic diagrams are shown in Figure 8.3.1-5. Typical schematic diagrams for motor operated valve and dc solenoid operated valve are also shown on Figure 8.3.1-5. The control power to the digital I&C systems and digital protection relays are provided from I&C power supply system or the plant dc power systems. The power quality, with respect to voltage stability, frequency, harmonic content, ripple, etc., of the I&C power supply systems and the plant dc power systems is not affected by system disturbances on the plant ac power systems. The equipment of the I&C power supply systems and the dc power systems are specified and factory tested to provide an acceptable level of power quality that is suitable for satisfactory operation of the digital I&C systems and digital protection relays.

8.3.1.2 Analysis

The US-APWR Class 1E ac power systems conform to the requirements of NRC regulations and GDC identified in Table 8.1-1 in Section 8.1. The system design, installation and operation conform to the guidance of RGs and BTPs identified in Table 8.1-1 in Section 8.1. Specifically, the safety Class 1E ac power systems and its components conform to the requirements of GDCs 2, 4, 17, 18, 33, 34, 35, 38, 41, 44 and 50 of Appendix A to 10 CFR 50; and the system design, installation, testing and operation are in accordance with regulatory guidance provided in RG 1.6, RG 1.9, RG 1.32, RG 1.47, RG 1.53, RG 1.63, RG 1.75, RG 1.106, RG 1.118, RG 1.153, RG 1.155, RG 1.160, RG 1.182 and RG 1.204.

8.3.1.2.1 Compliance with General Design Criteria

- Criterion 2 – Design bases for protection against natural phenomena

  All equipment and components of the safety-related Class 1E ac power systems are located in seismic category I building and their mounting and installations are seismically designed. The Class 1E ac power systems are designed to withstand the effects of natural phenomena such as design basis earthquake, tornado, hurricane, flood, tsunami, or seiche without losing the capability to perform their intended safety functions. Compliance to GDC 2 for all safety-related structures, systems, and components is generically addressed in Section 3.1.

- Criterion 4 – Environmental and dynamic effect design bases

All equipment and components of the safety-related Class 1E ac power systems are designed to withstand the effects of, and be compatible with, the environmental conditions associated with normal operation, maintenance, testing and postulated accidents; and are appropriately protected against dynamic effects that may result from equipment failures, including missiles. The safety-related ac power systems are designed to perform their intended safety functions during normal, abnormal, accident and post-accident conditions. The safety-related ac power systems are comprised of four independent trains that are electrically isolated and physically separated. The major electrical distribution equipment of each train are located in separate electrical rooms with redundant train safety-related HVAC system. There are no high or moderate energy lines or missile generating rotating equipment in the safety-related electrical equipment rooms. All equipment and components of the safety-related ac power systems are qualified for Class 1E application in accordance with IEEE Std 323 (Reference 8.3.1-6) and all applicable IEEE equipment qualification standards. Compliance to GDC 4 for all safety-related SSCs is generically addressed in Section 3.1.

- Criterion 5 – Sharing of structures, systems and components

  US-APWR is a single unit plant with no common safety-related electric power system and therefore, this GDC is not applicable to US-APWR.

- Criterion 17 – Electric power systems

  The safety-related ac power systems are comprised of four independent and redundant systems, each with its own Class 1E GTG, 6.9kV switchgear, 480V load center, motor control center, UPS and associated power distribution equipment. Any two of the four trains are required to be operable to mitigate any abnormal or PA conditions. Hence, the system is capable to perform its safety functions assuming a single failure and one train being out of service for maintenance. This designed provision of redundancy and independence is more conservative than what is required by GDC 17. The Class 1E GTG and the ac power system distribution equipment and components including all cables and circuits have sufficient capacity and capability to perform their associated safety functions during all normal and emergency modes of plant operation including DBEs. The safety-related ac power system conforms to NRC guidance provided in RGs 1.6, 1.9, 1.32, 1.53, 1.75, 1.153 and 1.155 (Reference 8.3.1-18, 8.1-2, 8.3.1-19, 20, 2, 5 and 21), and NUREG/CR-0660 (Reference 8.3.1-22). Compliance to GDC 17 is also generically addressed in Section 3.1.

- Criterion 18 – Inspection and testing of electric power systems

  The safety-related ac power system has been designed to permit periodic inspection and testing of key areas and features in order to assess system continuity and availability, and verify the condition of system components. The ac power systems are designed to provide the capability to perform integral periodic testing of Class 1E systems. The system design conforms to NRC guidance provided in RGs 1.9, 1.32, 1.47, 1.118, 1.153 (Reference 8.1-2, 8.3.1-19, 23, 24 and 5) and BTP 8-5 (Reference 8.3.1-25). Compliance to GDC 18 is also generically addressed in Section 3.1.

- Criteria 33, 34, 35, 38, 41 and 44:

  These GDC set requirements for certain safety systems for which access to both onsite and offsite power sources must be provided. The indicated safety systems have sufficient redundancy such that the system's safety function can be achieved assuming a single failure. In general, all plant safety systems have four redundant trains, with four different load groups. The four trains of safety-related load groups and associated instrumentation and control devices are distributed to four different safety-related power distribution systems that have access to both offsite and onsite power sources. The safety system functions can be achieved by operation of any two of the four safety trains, assuming one train inoperable due to a single failure and one train out of service for maintenance. The safety-related ac power systems conform to the requirements of these GDC by complying with the minimum requirements of GDC 17. Compliance to these GDC is generically addressed in Section 3.1.

- Criterion 50 – Containment design basis

  No equipment or component of the safety ac power systems is located inside the containment vessel. The cables of the ac circuits that feed ac loads inside the containment vessel go through electric penetration assemblies. The design, construction, testing, qualification and installation of electric penetration assemblies used for Class 1E and non-Class 1E ac circuits conform to the requirements of IEEE Std 317 (Reference 8.3.1-17). The electrical penetration assemblies are qualified in accordance with and IEEE Std 323 (Reference 8.3.1-6) and IEEE Std 317 (Reference 8.3.1-17) for the worst temperature and pressure condition resulting from any LOCA without exceeding the design leakage rate. The protection system design of the electric penetration assemblies conforms to the applicable criteria of IEEE Std 741 (Reference 8.3.1-7) and RG 1.63 (Reference 8.3.1-26). All electrical penetrations are protected with both primary and back up protection.

8.3.1.2.2 Conformance with Regulatory Guidance

- RG 1.6, "Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems"

  Conformance to this regulatory guide for regulatory positions identified in Standard Review Plan (SRP) (Reference 8.3.1-27) Subsection 8.3.1 is described below:

  Regulatory position D.1 – The electrically powered ac safety loads are separated into four different redundant load groups, powered by four redundant trains of the safety-related ac power system. Since any two of the four redundant trains are required for minimum safety functions, the ac power system design conforms to the single failure criterion while one redundant train is out of service.

Regulatory position D.2 – Each Class 1E ac load group has two connections to the preferred offsite power sources and to an onsite standby power source. The onsite standby power source of one load group has no automatic connection to any other redundant load group.

Regulatory Position D.4 – The redundant onsite ac power sources and their distribution systems are completely independent. The equipment, components and circuits of each safety train and non safety load groups are electrically isolated and physically separated from each other. There is no provision for automatic parallel operation of offsite and onsite power sources. No provisions exist for automatically connecting one load group to another load group. No provisions exist for automatically transferring loads between redundant power sources.

Regulatory position D.5 – One Class 1E GTG is used as the standby power source for each Class 1E ac load group. The generator size and ratings are comparable to generators used in other United States (US) nuclear plants. Each generator is driven by one prime mover which is a GTG. Use of a GTG is not typical in US nuclear power plants. Suitability of GTG application in the onsite Class 1E standby power source is addressed in a separate report.

- RG 1.9, "Application and Testing of Safety-Related Diesel Generators in Nuclear Power Plants"

  This RG endorses IEEE Std 387 (Reference 8.1-1) with some exceptions that pertain to the design, qualification, and periodic testing of diesel generators. The emergency power supply system for the US-APWR is GTG, not a diesel generator set. However, the GTG will be qualified in accordance with IEEE Std 387 (Reference 8.1-1). The GTG is designed to comply with requirements specified by RG 1.9 (Reference 8.1-2).

- RG 1.32, "Criteria for Power Systems for Nuclear Power Plants"

  This regulatory guide endorses IEEE Std 308 (Reference 8.2-4) with an exception that pertains to sharing of dc power systems at multi-unit nuclear power plants. The US-APWR ac power system design, operation and testing fully conform to the requirements of IEEE Std 308 (Reference 8.2-4). The exception cited in this regulatory guide is not applicable to US-APWR since it is a single unit plant.

- RG 1.47, "Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems"

This regulatory guide requires indication of the bypass or inoperable status of safety-related functions. US-APWR design is in accordance with this requirement.

- RG 1.53, "Application of the Single-Failure Criterion to Safety Systems"

  This regulatory guide endorses IEEE Std 379 (Reference 8.3.1-28). This IEEE Standard provides guidance in the application of the single-failure criterion and presents an acceptable method of single-failure analysis. The Class 1E ac power system is comprised of four trains of completely independent systems, each with its own Class 1E GTG and power distribution equipment. The components and equipment of each train are electrically isolated and located in separate rooms in a seismic category I building with minimum 3-hour rated fire barrier between rooms. The HVAC systems that support operation of the Class 1E ac power system are powered from the redundant train Class 1E ac power system. Hence, any postulated design-basis event may render no more than one train of the Class 1E ac power system inoperable. Any two of the four trains are required to be operational to provide minimum safety function under any postulated design event. Hence, the Class 1E ac power system complies with the single-failure criterion, even when one train is out of service. As indicated in Subsection 6.1.4 of IEEE Std 379 (Reference 8.3.1-28), it is not necessary to consider the effect of failure of any component or equipment within a train for the purpose of satisfying the single-failure criterion.

- RG 1.63, "Electric Penetration Assemblies in Containment Structures for Nuclear Power Plants"

  This regulatory guide endorses IEEE Std 317 (Reference 8.3.1-17). Compliance to IEEE Std 317 (Reference 8.3.1-17) is discussed in Subsection 8.3.1.2.1, in the discussion of compliance to GDC 50 (Reference 8.1-3).

- RG 1.75, "Criteria for Independence of Electrical Safety Systems"

  This regulatory guide endorses IEEE Std 384 (Reference 8.3.1-1) with some exceptions and clarifications indicated in regulatory positions C (1) through C (5). The electrical isolation and physical separation of all Class 1E equipment and circuits between redundant trains, and between each train and non-Class 1E equipment and circuits, is in full compliance with the IEEE Std 384 (Reference 8.3.1-1) as endorsed by RG 1.75 (Reference 8.3.1-2). The Class 1E 6.9 kV switchgear, 480V Load Centers, 480V MCCs, MOV inverters, 480V MOV MCCs of each redundant trains are located in separate electrical rooms in the R/B. All Class 1E UPS units and other electrical distribution equipment of redundant I&C power systems are also located in separate rooms in the R/B.

  The Class 1E equipment and circuits that are designated as A1 or associated with A1 buses, are considered part of train A. During normal plant operations, the A1 buses are powered from A train power sources and the Class 1E power systems have four independent trains. Since only two trains are sufficient to mitigate DBE condition, the Class 1E power systems meet the single failure criterion with one train out of service for maintenance. During maintenance of A-Class 1E GTG, the A1 buses are powered from train B sources. During maintenance of B–Class 1E GTG, the A1 buses are powered from train A power sources. During this maintenance period of A or B train GTGs, for analysis purposes, the A and B trains are considered as one train, completely independent from trains C and D. Availability of any two of these three trains is sufficient to mitigate any DBE.

Similarly, the Class 1E equipment and circuits that are designated as D1 or associated with D1 buses, are considered part of train D. During normal plant operation, the D1 buses are powered from D train power sources and the Class 1E power systems have four independent trains. Since only two trains are sufficient to mitigate DBE condition, the Class 1E power systems meet the single failure criterion with one train out of service for maintenance. During maintenance of D-Class 1E GTG, the D1 buses are powered from train C sources. During maintenance of C-Class 1E GTG, the D1 buses are powered from train D power sources. During this maintenance period of D or C train GTGs, for analysis purposes, the D and C trains are considered as one train, completely independent from trains A and B. Availability of any two of these three trains is sufficient to mitigate any DBE.

The following is an example of the methodology used to maintain train independence and redundancy during A train GTG online maintenance. Prior to declaring the A train GTG inoperable for maintenance, the B, C, and D trains are verified to be operable with C and D trains in a normal (not paired) configuration. The A and B trains can then be declared to be a single (paired) train. At this point, there are three 50% load groups and two 100% load groups operable that are fully independent and redundant (A/B, C, and D).

Once A and B are declared to be a single (paired) train, 480V AC load center A1 and 120V AC panelboard A1, as well as 125V dc switchboard A1, are transferred live from their A train normal power supplies to their B train power supplies. With these transfers complete, the A train GTG can be removed from service for maintenance. The operable 50% load groups are B, C, and D. The operable 100% load groups are A1 (powered from B train sources) and D1. A and B trains remain a single (paired) train, but the A train 50% loads are considered available, but not operable, as a result of the inoperability of the A train GTG.

Upon completion of A train GTG on-line maintenance, the A train GTG is declared operable first. Then, the power supply cross tie breaker from the B train source on the A train panelboard which feeds to the A train PSMS cabinet is opened. Finally, the 480V AC load center A1 and the 120V AC panelboard A1, as well as the 125V dc switchboard A1, are transferred live back to their normal power sources on the A train. The A and B trains can then be declared separate operable trains that are fully independent and redundant.

Only one GTG is permitted to be out of service for maintenance during all modes of plant operation, except the refueling mode. When all four trains are available, operability of least one train of trains A or D, in conjunction with one of the three remaining trains, is required to mitigate a DBE condition.

- RG 1.81, “Shared Emergency and Shutdown Electric Systems for Multi-Unit Nuclear Power Plants”

  The US-APWR is a single unit plant, therefore this regulatory guide is not applicable to US-APWR.

- RG 1.106, “Thermal Overload Protection for Electric Motors on Motor-Operated Valves”

  This RG requires ensuring that safety-related MOVs whose motors are equipped with thermal overload protection devices integral with the motor starter will perform their function. Design of the MOVs overload protection devices is in accordance with this requirements.

- RG 1.118, “Periodic Testing of Electric Power and Protection Systems”

  This regulatory guide endorses IEEE Std 338 (Reference 8.3.1-29) with some exceptions and clarifications indicated in regulatory positions C (1) through C (3). The IEEE Std 338 (Reference 8.3.1-29) provides design and operational criteria for the performance of periodic testing as part of the surveillance program of nuclear plant safety systems. The IEEE Std 338 (Reference 8.3.1-29) was reissued in 2006 and the surveillance program for the Class 1E ac power system conforms to the criteria provided in the 2006 version of the IEEE standard. The regulatory positions cited in RG 1.118 (Reference 8.3.1-24) are of a clarifying nature and the intent of these regulatory positions is considered in developing the periodic testing program for the Class 1E ac power system.

- RG 1.153, “Criteria for Safety Systems”

  This regulatory guide endorses IEEE Std 603 (Reference 8.3.1-4) with some clarifications regarding applicability and use of industry standards referenced in Section 3 of IEEE Std 603 (Reference 8.3.1-4). IEEE Std 603 (Reference 8.3.1-4) provides minimum functional and design requirements for the power, instrumentation, and control portions of safety systems for nuclear power generating stations. The IEEE Std 603 (Reference 8.3.1-4) was reissued in 1998 and this later version of the standard is used to establish the minimum functional and design requirements for the safety dc power system. The regulatory positions cited in RG 1.153 (Reference 8.3.1-5) are of clarifying nature and the intent of these regulatory positions is considered in establishing the minimum functional and design requirements for the safety-related ac power system.

- RG 1.155, “Station Blackout”

This regulatory guide provides guidance for complying with 10 CFR 50.63 (Reference 8.2-5). The plant has two AAC power sources of which only one is required to be operational to cope with an SBO event. The AAC power source design, operation, testing, maintenance and associated quality assurance requirements conform to the guidance provided in RG 1.155. Power to all electrical loads that are required to be operational, is restored within one hour from the onset of an SBO event. AAC source power to only one Class 1E 6.9kV bus is required to cope with an SBO event. Non-Class 1E equipment and circuits that are associated with the AAC power sources are completely independent from the onsite Class 1E standby power sources and the offsite power sources. The Class 1E GTGs are not operated in parallel with the AAC GTGs except briefly during recovery from SBO. The AAC GTGs are not operated in parallel with offsite power sources except during testing of AAC GTGs and recovery from SBO. The AAC GTGs are of different manufacturer from the Class 1E GTGs.

- RG 1.160, "Monitoring the Effectiveness of Maintenance at Nuclear Power Plants"

  This regulatory guide endorses revision 2 of NUMARC 93-01 with some provisions and clarifications for complying with 10 CFR 50.65 (Reference 8.2-7). Conformance to this regulatory guide is generically addressed in Section 1.9.

- RG 1.182, "Assessing and Managing Risk Before Maintenance Activities at Nuclear Power Plants"

  This regulatory guide endorses Section 11 of NUMARC 93-01 (Reference 8.2-6) dated February 11, 2000 with some provisions and clarifications for complying with 10 CFR 50.65(a)(4) (Reference 8.2-7). Conformance to this regulatory guide is generically addressed in Section 1.9.

- RG 1.204, "Guidelines for Lightning Protection of Nuclear Power Plants"

  This RG endorses four IEEE Standards, IEEE Std 665 (Reference 8.2-8), IEEE Std 666 (Reference 8.2-9), IEEE Std 1050 (Reference 8.2-10) and IEEE Std C62.23 (Reference 8.2-11), in their entirety with one exception to IEEE Std 665 (Reference 8.2-8), Subsection 5.7.4, which misquotes Subsection 4.2.4 of IEEE Std 142 (Reference 8.2-12). The US-APWR onsite power supply design fully confirms to the requirements of the endorsed IEEE standards that pertain to the lightning protection of nuclear power plants.

8.3.1.3 Electrical Power System Calculations and Distribution System Studies for AC System

Load flow, voltage regulation and short circuit studies are performed using the computer software program titled Electrical Transient Analyzer Program (ETAP) published by Operation Technology, Inc. The ETAP computer software program conforms to the requirements of 10 CFR Part 21 (Reference 8.3.1-36); 10 CFR Part 50 Appendix B (Reference 8.3.2-11); and American Society of Mechanical Engineers (ASME) NQA-1

(Reference 8.3.1-37). Onsite ac power system calculations are presented in Technical Report MUAP-09023 (Reference 8.3.1-38).

8.3.1.3.1 Load Flow/Voltage Regulation Studies and Under-/Overvoltage Protection

Load flow studies are performed to evaluate acceptable voltage range is maintained at equipment terminal in worst case loading condition. Voltage drop at equipment terminal is also calculated in largest motor starting condition. As a result, terminal voltage of equipment meets the acceptable voltage range indicated in Table 8.3.1-2.

8.3.1.3.2 Short Circuit Studies

Short circuit studies are performed to determine the magnitude of the prospective currents flowing throughout the power system due to a fault occurrence. The studies are performed to calculate most severe fault condition. This condition is a three phase bolted short circuit at the output terminal of a circuit breaker in the onsite ac distribution system. The studies are performed with ETAP based on ANSI/IEEE C37 standards. The acceptance criteria are that the calculated maximum short circuit current conforms to applicable breaker capability. Table 8.3.1-1 shows the breakers nominal ratings for the ac power system. The COL Applicant is to perform short circuit studies to confirm breaker ratings.

8.3.1.3.3 Equipment Sizing Studies

The ac power system equipment sizing is evaluated with the use of a spreadsheet. The spreadsheets of UATs, RATs and MV buses are shown in Table 8.3.1-3. The spreadsheets of the Class 1E GTGs are shown in Table 8.3.1-4. The spreadsheets of the AAC GTGs are shown in Table 8.3.1-5 and 8.3.1-6.

Main ac power system equipment ratings are listed in Table 8.3.1-1.

8.3.1.3.4 Equipment Protection and Coordination Studies

Onsite electrical system protection and coordination are performed to limit the extent and duration of the interruption in power supply whenever a circuit fault occurs on any portion of the onsite ac power system, and to minimize damage to the system components involved in the fault. The studies are performed in accordance with IEEE Std 242 (Reference 8.3.1-39). Protection coordination is dependent on the characteristics of installed protective devices. Therefore the studies are to be performed by the COL Applicant.

Class 1E equipment protection is described in Subsection 8.3.1.1.2.5.

8.3.1.3.5 Insulation Coordination (Surge and Lightning Protection)

Insulation coordination studies are performed in accordance with IEEE Std 1313.1 (Reference 8.3.1-40) and IEEE Std 1313.2 (Reference 8.3.1-41). Lightning protection is site-specific design as described in Subsection 8.3.1.1.11. Therefore, insulation coordination is to be provided by the COL Applicant.

8.3.1.3.6 Power Quality Limits

Onsite electrical equipment, such as motors, transformers and switchgears etc., are susceptible to poor power quality. Component heating may increase by this issue. Class 1E power quality meets IEEE Std 519 (Reference 8.3.1-42). Total harmonic distortion is maintained within acceptance criteria to keep appropriate power quality in accordance with this standard.

The digital control and protection system are supplied from the UPS unit. Output power of the UPS ensures adequate distortion to maintain performance of the digital control and protection system. Power quality for protective devices is also ensured within the devices required limit.

8.3.2 DC Power System

8.3.2.1 System Description

The onsite dc power system provides a reliable source of continuous power for controls, instrumentation, and dc motors. The onsite dc power system is comprised of independent Class 1E and non-Class 1E dc power systems. The Class 1E dc power system is comprised of four independent systems, one for each safety train. The non-Class 1E dc power system is also comprised of four separate dc power systems. Each Class 1E and non-Class 1E dc power system is provided with its own battery, battery charger and power distribution equipment.

The Class 1E dc power system provides reliable continuous power to the plant safety systems dc loads and the Class 1E I&C power supply system. In addition, it provides power to the emergency lighting systems for the vital areas. The non-Class 1E dc power system provides reliable continuous dc power to the plant non safety system dc loads and to the non-Class 1E I&C power supply system. Operation of the non-Class 1E dc power system is not required for coping with design-basis events. The safety-related dc loads powered by the Class 1E dc power system are listed in Table 8.3.2-1.

8.3.2.1.1 Class 1E DC Power System

The Class 1E dc power system consists of four independent power supply systems, identified as A, B, C and D trains. The system configuration is depicted in Figure 8.3.2-1. Each system consists of a main distribution switchboard fed from a battery and a battery charger. During normal operation, the dc system is powered by the battery charger and the battery is in float charge condition. Each battery charger is fed from a Class 1E 480V MCC of the same train. During all normal and emergency plant operating and shutdown conditions, the battery chargers are continuously powered from the 480V Class 1E MCCs, which are continuously powered from either offsite or onsite emergency power sources. In case of a LOOP, or a LOOP and coincident LOCA, the ac power supply to the battery chargers is restored within 100 seconds, the maximum time required for the onsite Class 1E GTG to be started. For conservatism, the batteries are sized to carry the worst-case dc load profile for a duration of two hours, assuming loss of a battery charger. The loading conditions of a LOOP and a LOOP concurrent with a LOCA have been considered to determine the worst-case load profile for the battery. In addition, the adequacy of the battery for SBO loading conditions for a duration of one hour is verified.

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 within 24 hours. The dc system is ungrounded with a nominal system voltage 125V. The maximum and minimum voltages at the battery terminals are 140V and 108V respectively.

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 other 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 spare battery charger AB is powered from A-AAC MCC and B-AAC MCC. Similarly, the spare battery charger CD is powered from A-AAC MCC and B-AAC MCC. During a LOOP, the non-Class 1E MCC permanent buses are powered from AAC sources. Each spare battery charger has two mechanically interlocked input circuit breakers and two mechanically interlocked output circuit breakers. Two non-Class 1E circuits from each spare charger are routed to the two trains of the Class 1E 125V dc switchboards. At each train of the Class 1E 125V dc switchboard, there are two mechanically interlocked input circuit breakers. Normal input to the Class 1E 125V dc switchboard is from the Class 1E battery charger, and other alternate input is from the non-Class 1E spare battery charger. These mechanical interlock features preclude parallel operation of normal and spare charger, spare battery charger feeding two switchboards and two MCCs feeding one battery charger. The spare battery chargers have the same capacity as of the Class 1E battery chargers.

Four train safety system dc loads are distributed on the four redundant Class 1E dc switchboards A, B, C, and D. Four train safety system loads are designed to perform their function with any two out of four. Two train safety system dc loads are distributed on Class 1E 125V dc switchboards A1 and D1. A1 switchboard is train A and can be powered from train B. Similarly, D1 switchboard is train D and can be powered from train C. The A1, A2, B, C, D1, and D2 MOV MCCs are powered by their same train MOV inverters and supply various MOVs. The normal electrical alignment for these MOV inverters is A1 and A2 supplied by A train, B supplied by B train, C supplied by C train, and D1 and D2 supplied by D train. Alternate electrical alignments for these MOV inverters is A1 and A2 supplied by B train, B supplied by A train, C supplied by D train, and D1 and D2 supplied by C train. The A1, A2, D1, and D2 train MOV inverters are directly connected to the A1 and D1 dc switchboards, respectively, and are transferred from their normal train power supplies to their alternate train power supplies when the A1 and D1 dc switchboards are transferred. The B and C train MOV inverters are directly supplied from the B and C train dc switchboards and must be manually transferred to their alternate train power supplies.

Prior to a maintenance outage of train A GTG, the A1 dc switchboard is manually connected to the train B Class 1E dc switchboard. Similarly, prior to a maintenance outage of train D GTG, the D1 dc switchboard is manually connected to the train C Class 1E dc switchboard. The A1, A2, D1, and D2 MOV MCC inverters transfer with the A1 and D1 dc switchboards. There are no automatic tie connections between the redundant Class 1E trains. The tie connection between train B switchboard and train A switchboard A1 and between train C switchboard and train D switchboard D1 are closed manually during maintenance of the Class 1E A-GTG or Class 1E D-GTG respectively. Similarly, the tie connection between train A switchboard and train B MOV Inverter and between train D switchboard and train C MOV Inverter are closed manually during maintenance of the Class 1E B-GTG or Class 1E C-GTG respectively. The tie circuit breakers are key operated to limit possibility of cross tie during normal operation but allow for a live transfer during a GTG online maintenance.

The Class 1E dc power systems are designed as safety-related equipment in accordance with IEEE Std 308 (Reference 8.2-4) and IEEE Std 946 (Reference 8.3.2-1). The system design and all equipment and circuits are in compliance with applicable GDC, IEEE standards, and regulatory guides listed in Subsection 8.1.5.3. The scope of compliance includes physical separation, electrical isolation, equipment environmental qualification, effects of single failure, capacity of battery and battery charger, instrumentation and protective devices, and surveillance test requirements. The Class 1E batteries are sized in accordance with IEEE Std 485 (Reference 8.3.2-2) and their installation conforms to the guidance of IEEE Std 484 (Reference 8.3.2-3). The initial and routine testing of the batteries will be performed following manufacturer's recommendations and IEEE Std 450 (Reference 8.3.2-4). The Class 1E dc system is designed so that no single failure in any train of the 125V dc system while a separate train has been taken out of service for maintenance or repair, results in conditions that prevent safe shutdown of the plant. Nominal ratings of major Class 1E dc equipment are shown in Table 8.3.2-3. Short circuit rating is to be confirmed by the COL Applicant.

Class 1E dc power system is provided with the following alarms and available displays in the MCR:

- switchboard bus voltage and battery current displays
- dc system ground fault alarm
- battery charger output voltage low alarm
- battery charger ac input failure alarm
- battery charger dc output failure alarm
- battery circuit breaker/disconnect switch open alarm
- battery charger circuit breaker open alarm
- battery test circuit breaker closed alarm
- battery charger common failure/trouble alarm.

The equipment and circuit layout of the dc system provide physical separation of the equipment, cabling, and instrumentation essential to plant safety. The batteries are located in temperature-controlled ventilated rooms, separated from each other and away from the battery chargers and power distribution equipment. All components of the system are located in seismic category I structures.

Class 1E Batteries

The 125V dc Class 1E batteries have sufficient stored capacity, without reliance on the associated battery charger, to independently supply power to the safety-related loads continuously for two hours. The batteries are sized in accordance with the method recommended in IEEE Std 485 (Reference 8.3.2-2). The worst-case duty cycle is based on loading requirements subsequent to a LOOP and a LOOP concurrent with a LOCA. In addition, the adequacy of the battery for SBO loading condition for a duration of one hour is verified. The design bases for the battery sizing are 65°F ambient temperature, 25% aging factor, 1.8V per cell end voltage and10% design margin. The allowable minimum and maximum battery terminal voltages are 108V (1.8 V per cell) and 140V (2.33V per cell), respectively. The maximum equalizing charge voltage is limited to 140 V dc, as recommended by industry standards for lead-acid batteries. The I&C power supply system inverters are designed to supply 120V ac power with dc power less than 140V and more than 108V at the batteries terminal.

The batteries are installed in accordance with IEEE Std 484 (Reference 8.3.2-3) and are qualified per IEEE Std 535 (Reference 8.3.2-5). Each battery train is located in a separate battery room in the PS/B. The battery rooms are ventilated to the outside to preclude hydrogen concentration of more than 1%. A safety-related ventilation system is provided for associated Class 1E battery room as described in Subsection 9.4.5.2.2. Safety-related heating system is provided to maintain the battery room temperature at no less than 65°F. The battery banks are designed to permit inspection and replacement of individual cells.

Class 1E Battery Chargers

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 an other 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. A failure mode effect analysis for the interaction of the non-Class 1E spare battery charger on the Class 1E dc power system is shown in Table 8.3.2-4. The Class 1E battery charger of each train is located in a separate room, identified as “Class 1E Battery Charger Room” located in the PS/B, adjacent to battery room of same train. The spare battery chargers AB and CD are located in Spare Battery Charger Rooms of the PS/B, respectively. The battery chargers are full wave, silicon-controlled rectifiers, housed in a NEMA 1 ventilated freestanding enclosure. The battery chargers operate from 480V ac 3 phase 60Hz power supply, and are capable of float charging the batteries with provision for manual equalization of the batteries.

Each 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. Each battery charger has an input ac and an output dc circuit breaker for the purpose of power source isolation and required protection. The battery chargers are constant voltage type, with adjustable output voltage and are capable of operating as a battery eliminator. The output float and equalizing voltages are adjustable. The battery eliminator feature enables the dc system to operate satisfactorily in case of inadvertent disconnection of the battery. The battery charger output voltage variation is limited to ±1% with or without battery connected. The battery charger output is ungrounded and filtered, the maximum output ripple for the battery charger is limited to 30mV root-mean-square with the battery and less than ±2% root-mean-square without the battery.

The battery charger output is of the current limiting type, adjustable between 110 to 125% of its rating, in order to hold down the output current in the event of a short circuit or overload on the dc side. The battery chargers have built in blocking diodes to prevent the battery charger or the ac system to become a load on the battery. Each battery charger is provided with a local dc output ammeter and voltmeter. Each battery charger is provided with a 'high dc voltage shutdown relay' that opens main ac supply breaker to the charger and provides local alarm. Local alarms are provided for 'battery charger high dc voltage', 'battery charger low dc voltage', 'battery charger output breaker open', 'failure of battery charger ac input' and 'failure of battery charger dc output'. These local alarms are combined to generate 'battery charger trouble alarm' for indication in the MCR.

Class 1E DC Distribution System Equipment

Each train of the dc power system has a main distribution switchboard, located in separate Class 1E Battery Charger Room of the PS/B adjacent to their associated battery rooms of the same train. Each switchboard is connected to its associated battery and battery charger of same train, as depicted in Figure 8.3.2-1. The Class 1E switchboards employ fusible disconnect switches as input and output circuit protection devices. All input and output circuit protection devices have adequate short circuit and continuous current ratings. The main bus bars are rated to carry the load currents of battery duty cycles as indicated in Tables 8.3.2-1. The main bus bars are also insulated and braced to withstand the mechanical forces resulting from a worst-case short circuit current. The battery positive and negative leads are routed in separate non magnetic conduits. The switchboard bus is provided with instrumentation to indicate, locally and in the MCR, the bus voltage and battery charge/discharge current. The switchboard bus also has ground detection voltmeter and local and remote alarm in MCR for system ground fault. Breaker open alarm is provided in the MCR for the input breakers from the battery and battery charger. Alarms are provided in the MCR for bus undervoltage and for battery test circuit breaker closed condition. The major dc loads are fed directly from the dc switchboard, and smaller dc loads are fed from dc panelboards connected to the dc switchboard. The main circuit protection devices and feeder circuit protection devices located in the switchboards have selective coordination with all downstream protective devices in accordance with IEEE Std 242 (Reference 8.3.1-39).

8.3.2.1.2 Non-Class 1E DC Power System

The non-Class 1E dc power system consists of four separate power supply systems, identified as N1, N2, N3 and N4. The non-Class 1E dc power system configurations are depicted in Figure 8.3.2-1. Each system consists of a main distribution switchboard, fed from a battery and a battery charger. In addition, there are two spare battery chargers; the N12 battery charger is for buses N1 and N2, and the N34 battery charger is for buses N3 and N4. During normal operation of the dc power system, the battery is in float charge condition and the system is powered by the battery charger connected to the permanent 480V ac system. The N1 and N3 battery chargers are fed from 480V permanent MCCs P11 and P12, respectively. The P11 and P12 MCCs are normally fed from RAT3, or from UAT3 when RAT3 is unavailable, or from the onsite gas-turbine generator A-AAC power source during a LOOP. Similarly, the N2 and N4 battery chargers are fed from 480V permanent MCCs P21 and P22, respectively. The P21 and P22 MCCs are normally fed from RAT4, or from UAT4 when RAT4 is unavailable, or from the onsite gas-turbine generator B-AAC power source during a LOOP.

The spare battery charger N12 is powered from 480V MCC bus N3, or from 480V permanent MCC bus P12 via a manual transfer switch. The MCC bus N3 is normally fed from UAT3, or RAT3 when UAT3 is unavailable. The permanent MCC bus P12 is normally fed from UAT3, or RAT3 when UAT3 is unavailable, or from the onsite gas-turbine generator A-AAC power source during a LOOP or an SBO condition. Similarly, the spare battery charger N34 is powered from 480V MCC bus N4 or from 480V permanent MCC bus P21 via a manual transfer switch. The MCC bus N4 is normally fed from UAT4, or RAT4 when UAT4 is unavailable. The permanent MCC bus P21 is normally fed from UAT4, or RAT4 when UAT4 is unavailable, or from the onsite gas-turbine generator B-AAC power source during LOOP or SBO condition.

During all normal and emergency plant operating and shutdown conditions, the battery chargers are continuously powered from the 480V permanent MCCs, which are continuously powered from either offsite or onsite AAC power sources. In case of a LOOP or SBO condition, the non-Class 1E battery chargers are available within one hundred seconds, the maximum time required for the onsite AAC power sources to be operable and provide power to the battery chargers. During this one hundred second period, the battery provides power to the dc power system. For conservatism, the batteries are sized to carry the worst case dc load profile for a duration of one hour, assuming a failure of a battery charger and the spare charger unavailable. The loading conditions following a LOOP and an SBO have been considered to determine the worst case load profile for the battery. 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 within 24 hours. The dc system is ungrounded with a nominal system voltage 125V. The maximum and minimum voltages at the battery terminals are 140V and 108V respectively.

The design of the non-Class 1E dc power systems conform to the recommended guidance of IEEE Std 946 (Reference 8.3.2-1). The system design and all equipment and circuits are in compliance with applicable IEEE standards listed in Subsection 8.1.5.3. The non-Class 1E batteries are sized in accordance with IEEE Std 485 (Reference 8.3.2-2) and their installation conforms to the guidance of IEEE Std 484 (Reference 8.3.2-3). The initial and routine testing of the batteries will be performed following manufacturer’s recommendations and IEEE Std 450 (Reference 8.3.2-4). The non-Class 1E dc system is not specifically designed to withstand a single active failure; however, they are divided in four separate power supply systems corresponding to four separate ac and dc load and power supply groups. Nominal ratings of major non-Class 1E equipment are shown in Table 8.3.2-3. Short circuit rating is to be confirmed by the COL Applicant.

The batteries are located in ventilated rooms, away from associated battery chargers and power distribution equipment. The equipment and components of the system are located in the A/B and the T/B.

Non-Class 1E Batteries

The 125V dc non-Class 1E batteries have sufficient stored capacity without reliance on the associated battery charger to independently supply power to the required non safety-related loads continuously for one hour. The batteries are sized in accordance with the method recommended in IEEE Std 485 (Reference 8.3.2-2). The worst case duty cycle are based on loading requirements subsequent to LOOP and SBO conditions. The normal and worst case loading requirements that are imposed on the non-Class 1E 125V dc systems N1 through N4 are shown on Tables 8.3.2-2. The design bases for the battery sizing are 65°F ambient temperature, 25% aging factor, 1.8V per cell end voltage and 10% design margin. The allowable minimum and maximum battery terminal voltages are 108V (1.8 V per cell) and 140V (2.33V per cell), respectively. The maximum equalizing charge voltage is limited to 140 V dc, as recommended by industry standards for lead-acid batteries. The non-Class 1E I&C power supply system inverters are designed to supply 120V ac power with dc input less than 140V and more than 108V.

The installation of the non-Class 1E batteries conforms to the recommendations provided in IEEE Std 484 (Reference 8.3.2-3). Each of the non-Class 1E batteries N1 through N4 is located in temperature controlled ventilated battery room in the A/B and the T/B. The battery rooms are ventilated to the outside to preclude a hydrogen concentration of more than 1%. Operability of the ventilation system is not essential for the design basis functioning of the battery system. Non safety heating system is provided to maintain the non-Class 1E battery room temperature no less than 65°F. The battery banks are designed to permit inspection and replacement of individual cells.

Non-Class 1E Battery Chargers

There are four non-Class 1E battery chargers, one for each power supply group of the non-Class 1E 125V dc power systems, identified as N1, N2, N3 and N4. In addition, there are two permanently installed non-Class 1E battery chargers, identified as N12 and N34. The N1 and N2 battery chargers are backed-up by the N12 battery charger via a manually-operated transfer switch. Similarly, the N3 and N4 battery chargers are backed-up by the N34 battery charger via a manually-operated transfer switch. The connections of the battery chargers to the main distribution switchboard buses are configured via manual transfer switches to preclude any parallel operation of two battery chargers. The non-Class 1E battery charger of each power supply group is located in the A/B and the T/B. The spare battery chargers N12 and N34 are located in the A/B and the T/B. The battery chargers are full wave, silicon-controlled rectifiers, housed in a NEMA 1 ventilated freestanding enclosure. The battery chargers operate from 480 V ac 3 phase 60Hz power supply, and are capable of float charging the batteries with provision for manual equalization of the charging of the batteries.

Each battery charger has the capacity to recharge its battery from the design minimum charge to 95% charged condition within 24 hours and simultaneously supply the normal dc loads of the associated 125V dc switchboard bus. Each battery charger has an input ac and an output dc circuit breaker for the purpose of power source isolation and required protection. The battery chargers are of constant voltage type, with adjustable output voltage and are capable of operating as battery eliminators. The output float and equalizing voltages are adjustable. The battery eliminator feature enables the dc system to operate satisfactorily in case of inadvertent disconnection of the battery. The battery charger output voltage variation is limited to ±1% with or without a battery connected. The battery charger output is ungrounded and filtered. The maximum output ripple for the battery charger is limited to 30mV root-mean-square with the battery, and less than ±2% root-mean-square without the battery.

The battery charger output is of the current limiting type, adjustable between 110 to 125% of its rating, in order to hold down the output current in the event of short circuit or overload on the dc side. The battery chargers have built in blocking diodes to prevent the battery charger or the ac system to become a load on the battery. Each battery charger is provided with local dc output ammeter and voltmeter. Each battery charger is provided with a ‘high dc voltage shutdown relay’ that opens the main ac supply breaker to the charger and provides a local alarm. Local alarms are provided for ‘battery charger high dc voltage’, ‘battery charger low dc voltage’, ‘battery charger output breaker open’, ‘failure of battery charger ac input’ and ‘failure of battery charger dc output’. These local alarms are combined to generate a ‘battery charger trouble alarm’ for indication in the MCR.

Non-Class 1E DC Distribution System Equipment

Each power supply group of the non-Class 1E dc power system has a main 125V dc distribution switchboard, identified as N1, N2, N3 and N4. These switchboards are located in the A/B and the T/B. Each switchboard is connected to an associated battery and battery charger of same power supply group, as depicted in Figures 8.3.2-1. The non-Class 1E switchboards employ fusible disconnect switches as input and output circuit protection device. All input and output circuit protection devices have adequate short circuit and continuous current ratings. For conservatism, the main bus bars are rated to carry continuously the required worst case load currents during the first minute of battery duty cycles, as indicated in Tables 8.3.2-2. The main bus bars are also braced to withstand the mechanical forces resulting from a worst case short circuit current. The switchboard bus is provided with instrumentation to indicate locally and in the MCR the bus voltage and battery charge/discharge current. The switchboard bus also has a ground detection voltmeter and local and remote alarms in the MCR for system ground fault. A breaker open alarm is provided in the MCR for the input breakers from the battery and battery charger. Alarms are provided in the MCR for bus undervoltage and for battery test circuit breaker closed condition. The major dc loads are fed directly from the dc switchboard, and smaller dc loads are fed from dc panelboards connected to the dc switchboard. The main circuit protection devices and feeder circuit protection devices located in the switchboards have selective coordination with all downstream protective devices in accordance with IEEE Std 242 (Reference 8.3.1-39).

Non-Class 1E Hydrogen Igniter Batteries

The 125V dc non-class 1E batteries for hydrogen igniter have sufficient stored capacity without reliance on the associated battery charger to independently supply power to the required hydrogen igniter continuously for twenty four hours after onset of a station blackout and loss of AAC. Dedicated batteries are provided to cope with a station blackout and loss of AAC. The hydrogen igniter batteries are classified as nonsafety-related. The location of the hydrogen igniter batteries on the 2nd floor of the auxiliary building ensures that they will be available during the severe accident flooding events. Additionally, to enhance their reliability to function following seismic events, the batteries will be the same type as those used in the Class 1E batteries but procured through the nonsafety-related procurement process.

8.3.2.2 Analysis

The US-APWR Class 1E 125V dc power system conforms to the requirements of NRC regulations and GDC identified in Table 8.1-1 in Section 8.1. The system design, installation and operation conform to the guidance of RGs and BTPs identified in Table 8.1-1 in Section 8.1. Specifically, the Class 1E 125V dc power system and its components conform to the requirements of GDC 2, 4, 17, 18, 33, 34, 35, 38, 41, 44 and 50 of Appendix A to 10 CFR 50; and the system design, installation, testing and operation are in accordance with regulatory guidance provided in RG 1.6, RG 1.32, RG 1.47, RG 1.53, RG 1.63, RG 1.75, RG 1.118, RG 1.128, RG 1.129, RG 1.153, RG 1.155, RG 1.160 and RG 1.182.

Since the DC systems are stand alone, which each train having its independent battery, battery charger, etc. all switching are manual. As a result no logic diagrams are required.

8.3.2.2.1 Compliance with General Design Criteria

- Criterion 2 – Design bases for protection against natural phenomena

  All equipment and components of the safety-related Class 1E 125V dc power system are located in a seismic category I building and their mounting and installations are seismically designed. The Class 1E 125V dc system is designed to withstand the effects of natural phenomena such as design basis earthquake, tornado, hurricane, flood, tsunami, or seiche without losing its capability to perform their intended safety functions. Compliance to GDC 2 for all safety-related SSCs is generically addressed in Section 3.1.

- Criterion 4 – Environmental and dynamic effect design bases

  All equipment and components of the safety-related 125V dc power system are designed to withstand the effects of, and be compatible with, the environmental conditions associated with normal operation, maintenance, testing and postulated accidents; and are appropriately protected against dynamic effects that may result from equipment failures, including missiles. The safety-related dc power system is designed to perform its intended safety functions during normal, abnormal, accident and post-accident conditions. The safety-related 125V dc power system is comprised of four independent trains that are electrically isolated and physically separated. The batteries of each train are located in a separate Class 1E battery room with safety-related ventilation system. The battery charger and the main distribution switchboard of each train are located in the Class 1E battery charger room for the same train, also provided with redundant train safety-related HVAC system. There are no high or moderate energy lines or missile generating rotating equipment in the Class 1E Battery Rooms or Class 1E Battery Charger Rooms. All equipment and components of the safety-related dc system are qualified for Class 1E application in accordance with IEEE Std 323 (Reference 8.3.1-6) and all applicable IEEE equipment qualification standards. Compliance to GDC 4 for all safety-related SSCs is generically addressed in Section 3.1.

- Criterion 5 – Sharing of structures, systems and components

  US-APWR is a single unit plant with no shared safety systems and therefore, this GDC is not applicable to US-APWR.

- Criterion 17 – Electric power systems

  The safety-related dc power system is comprised of four independent and redundant systems, each with its own battery, battery charger and associated power distribution equipment. Any two of the four trains are required to be operable to mitigate any abnormal or design-basis accident conditions. Hence, the system is capable of performing its safety functions assuming a single failure and one train being out of service for maintenance. This designed provision of redundancy and independence is more conservative than what is required by GDC 17. The safety batteries and the dc power system distribution equipment and components including all cables and circuits have sufficient capacity and capability to perform their associated safety functions during all normal and emergency modes of plant operation including DBEs. The safety-related 125V dc power system conforms to NRC guidance provided in RGs 1.6, 1.32, 1.53, 1.75, 1.128 and 1.153 (Reference 8.3.1-18, 19, 20, 2, 8.3.2-6 and 8.3.1-5). Compliance to GDC 17 is also generically addressed in Section 3.1.

- Criterion 18 – Inspection and testing of electric power systems

  The safety-related dc power system has been designed to permit periodic inspection and testing of key areas and features in order to assess system continuity and availability, and verify the condition of system components. The safety-related dc power system is designed to provide the capability to perform integral periodic testing of the system. The system design conforms to the NRC guidance provided in RGs 1.32, 1.47, 1.118, and 1.153 (Reference 8.3.1-19, 23, 24 and 5) and BTP 8-5 (Reference 8.3.1-25). Compliance to GDC 18 is also generically addressed in Section 3.1.

- Criteria 33, 34, 35, 38, 41 and 44:

  These GDC set requirements for certain safety systems for which access to both onsite and offsite power sources must be provided. The indicated safety systems have sufficient redundancy such that the system's safety function can be achieved assuming a single failure. In general, all plant safety systems have four redundant trains, with four different load groups. The four trains of safety-related load groups and associated instrumentation and control devices are distributed to four different safety-related power distribution systems that have access to both offsite and onsite power sources. The safety system functions can be achieved by operation of any two of the four safety trains, assuming one train inoperable due to a single failure and one train out of service for maintenance. The safety-related dc systems conform to the requirements of these GDC by complying with the minimum requirements of GDC 17. Compliance to these GDC is generically addressed in Section 3.1.

- Criterion 50 – Containment design basis

  No equipment or component of the Class 1E or non-Class 1E dc power system is located inside the C/V. The dc system ends at the last circuit protective device protecting a dc load. The dc loads are not part of the dc system. The cables of the dc circuits that feed dc loads inside the C/V go through electrical penetration assemblies. The design, construction, testing, qualification and installation of electrical penetration assemblies used for Class 1E and non-Class 1E dc circuits conform to the requirements of IEEE Std 317 (Reference 8.3.1-17). The electrical penetration assemblies are qualified in accordance with and IEEE Std 323 (Reference 8.3.1-6) and IEEE Std 317 (Reference 8.3.1-17) for the worst temperature and pressure condition resulting from any LOCA without exceeding the design leakage rate. The protection system design of the electric penetration assemblies conforms to the applicable criteria of IEEE Std 741 (Reference 8.3.1-7) and RG 1.63 (Reference 8.3.1-26). All electrical penetrations are protected with both primary and back up protection.

8.3.2.2.2 Conformance with Regulatory Guidance

- RG 1.6, “Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems”

  Conformance to this regulatory guide for regulatory positions identified in SRP (Reference 8.3.1-27) Subsection 8.3.2 is described below:

  Regulatory position D.1 - The electrically powered dc safety loads are separated into four different redundant load groups, powered by four redundant trains of the safety-related dc power system. Since any two of the four redundant trains are required for minimum safety functions, the dc system design conforms to the single failure criterion while one redundant train is out of service.

  Regulatory position D.3 –Each redundant train of the dc power system is energized by a battery and a Class 1E battery charger. In addition, there are two installed non-Class 1E spare battery chargers AB and CD. Non-Class 1E spare battery charger AB can be connected manually to replace any of the Class 1E chargers of the two redundant trains A or B. Similarly, the non-Class 1E spare battery charger CD can be connected manually to replace any of the Class 1E chargers of the two redundant trains C or D. The non-Class 1E spare battery chargers (AB & CD) do not have any safety function and are not required to support Class 1E system operation. These chargers are typically only used during maintenance on the Class 1E battery chargers. The battery-charger combination of one train has no automatic connection to any other redundant dc load group.

Regulatory Position D.4 – The redundant onsite dc power sources and their distribution systems are completely independent. The equipment, components and circuits of each safety-related train and non safety load groups are electrically isolated and physically separated from each other. There is no provision for automatic parallel operation of batteries or battery chargers. No provisions exist for automatically connecting one load group to another load group. No provisions exist for automatically transferring loads between redundant power sources. The installed spare charger can be manually placed in service to replace any one safety-related charger. Interlock has been provided to preclude parallel operation of two chargers due to operator error.

- RG 1.32, “Criteria for Power Systems for Nuclear Power Plants”

  This regulatory guide endorses IEEE Std 308 (Reference 8.2-4) with an exception that pertains to sharing of dc power systems at multi-unit nuclear power plants. The US-APWR dc power system design, operation and testing fully conform to the requirements of IEEE Std 308 (Reference 8.2-4). The exception cited in this regulatory guide is not applicable to US-APWR since it is a single unit plant.

- RG 1.47, “Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems”

  This regulatory guide requires indication of the bypass or inoperable status of safety-related functions. The US-APWR design is accordance with this requirement.

- RG 1.53, “Application of the Single-Failure Criterion to Safety Systems”

  This regulatory guide endorses IEEE Std 379 (Reference 8.3.1-28). This IEEE Standard provides guidance in the application of the single failure criterion and presents an acceptable method of single failure analysis. The Class 1E dc power system is comprised of four trains of completely independent systems, each with its own battery, battery charger and power distribution equipment. The components and equipment of each train are electrically isolated and located in separate rooms in seismic category I building with minimum 3-hour rated fire barrier between rooms. The HVAC systems that support operation of the Class 1E dc power system are powered from the redundant Class 1E ac power system. Any two of the four trains are required to be operational to provide minimum safety function under any postulated design event. Hence, the Class 1E dc power system complies with the single failure criterion, even when one train is out of service. As indicated in Subsection 6.1.4 of IEEE Std 379 (Reference 8.3.1-28), it is not necessary to consider the failure of any component or equipment within a train for the purpose of satisfying the single failure criterion.

- RG 1.63, “Electric Penetration Assemblies in Containment Structures for Nuclear Power Plants”

  This regulatory guide endorses IEEE Std 317 (Reference 8.3.1-17). Compliance to IEEE Std 317 (Reference 8.3.1-17) is discussed in Subsection 8.3.2.2.1, in the discussion of compliance to GDC 50 (Reference 8.1-3).

- RG 1.75, “Criteria for Independence of Electrical Safety Systems”

  This regulatory guide endorses IEEE Std 384 (Reference 8.3.1-1) with some exceptions and clarifications indicated in regulatory positions C (1) through C (5). Compliance to this regulatory guide with regards to the physical independence of circuits and electrical equipment that comprise or are associated with safety systems, is discussed in Subsection 8.3.1.2. As required by Subsection 6.3.1 of IEEE Std 384 (Reference 8.3.1-1), the Class 1E batteries of redundant trains are placed in separate, safety-class structures. Similarly, the redundant Class 1E battery chargers are also placed in separate rooms and their physical separation fully conforms to the requirements of section 5 of IEEE Std 384 (Reference 8.3.1-1).

  The Class 1E equipment and circuits that are designated as A1, or associated with A1 buses, are considered part of train A. During normal plant operations, the A1 buses are powered from A train power sources and the Class 1E power systems have four independent trains. Since only two trains are required to mitigate a DBE condition, the Class 1E power systems meet the single failure criterion with one train out of service for maintenance. During maintenance of the train A Class 1E GTG, the A1 buses are powered from train B sources. During maintenance of train B Class 1E GTG, the A1 buses are powered from train A power sources. For analysis purposes, during this maintenance period of A or B train GTGs, the A and B trains are considered as one train, completely independent from trains C and D. Availability of any two of these three trains is sufficient to mitigate any DBE. Similarly, the B MOV Inverter is normally powered from train B and powered from train A during online maintenance of train B Class 1E GTG.

  The Class 1E equipment and circuits that are designated as D1, or associated with D1 buses, are considered part of train D. During normal plant operation, the D1 buses are powered from D train power sources and the Class 1E power systems have four independent trains. Since only two trains are required to mitigate a DBE condition, the Class 1E power systems meet the single failure criterion with one train out of service for maintenance. During maintenance of the train D Class 1E GTG, the D1 buses are powered from train C sources. During maintenance of train C Class 1E GTG, the D1 buses are powered from train D power sources. For analysis purposes, during this maintenance period of D or C train GTGs, the D and C trains are considered as one train, completely independent from trains A and B. Availability of any two of these three trains is sufficient to mitigate any DBE. Similarly, C MOV Inverter is normally powered from train C and powered from train D during online maintenance of train C Class 1E GTG.

The following is an example of the methodology used to maintain train independence and redundancy during train A GTG online maintenance. Prior to declaring the train A GTG inoperable for maintenance, the B, C, and D trains are verified to be operable with C and D trains in a normal (not paired) configuration. The A and B trains can then be declared to be a single (paired) train. At this point, there are three 50% load groups and two 100% load groups operable that are fully independent and redundant (A/B, C, and D). Once A and B are declared to be a single (paired) train, 125V dc switchboard A1 as well as 480V AC load center A1 and 120V AC panelboard A1 are transferred live from their A train normal power supplies to their B train power supplies. With these transfers complete, the train A GTG can be removed from service for maintenance. The operable 50% load groups are B, C, and D. The operable 100% load groups are A1 (powered from B train sources) and D1. A and B trains remain a single (paired) train, but the A train 50% loads are considered available, but not operable, as a result of the inoperability of the train A GTG. Upon completion of train A GTG online maintenance, the train A GTG is declared operable first. Then, the power supply cross tie breaker from the B train source on the A train panelboard which feeds to the A train PSMS cabinet is opened. Finally, the 125V dc switchboard as well as the A1 480V AC load center are transferred live back to their normal power sources on the A train. The A and B trains can then be declared separate operable trains that are fully independent and redundant.

- RG 1.81, "Shared Emergency and Shutdown Electric Systems for Multi-Unit Nuclear Power Plants"

  The US-APWR is a single unit plant, therefore this regulatory guide is not applicable to the US-APWR.

- RG 1.106, "Thermal Overload Protection for Electric Motors on Motor-Operated Valves"

  The US-APWR does not have any dc MOV, therefore this regulatory guide is not applicable to the US-APWR.

- RG 1.118, "Periodic Testing of Electric Power and Protection Systems"

  This regulatory guide endorses IEEE Std 338 (Reference 8.3.1-29) with some exceptions and clarifications indicated in regulatory positions C (1) through C (3). The IEEE Std 338 (Reference 8.3.1-29) provides design and operational criteria for the performance of periodic testing as part of the surveillance program of nuclear plant safety systems. The IEEE Std 338 (Reference 8.3.1-29) was reissued in 2006 and the surveillance program for the Class 1E dc power system conforms to the criteria provided in the 2006 version of the IEEE standard. The regulatory positions cited in RG 1.118 (Reference

8.3.1-24) are of a clarifying nature and the intent of these regulatory positions is considered in developing the periodic testing program for the Class 1E dc power system.

- RG 1.128, "Installation Design and Installation of Vented Lead-Acid Storage Batteries for Nuclear Power Plants"

  This regulatory guide endorses IEEE Std 484 (Reference 8.3.2-3) with some stipulations as indicated in regulatory positions C.1 through C.10. The IEEE Std 484 (Reference 8.3.2-3) provides the criteria that should be used for storage, location, mounting, ventilation, instrumentation, preassembly, assembly and charging of vented lead-acid batteries. The US-APWR Class 1E batteries conform to the requirements of the IEEE Std 484 (Reference 8.3.2-3), including the stipulations of regulatory positions C.1 through C.10 of RG 1.128.

  Conformance to the regulatory positions is described below:

  Regulatory position C.1 – The recommended practice of IEEE Std 484 (Reference 8.3.2-3) is used in conjunction with IEEE Std 308 (Reference 8.2-4) (as endorsed by RG 1.32 (Reference 8.3.1-19)), IEEE Std 336 (Reference 8.3.2-7), IEEE Std 344 (Reference 8.3.1-12) (as endorsed by RG 1.100 (Reference 8.3.2-8)), IEEE Std 450 (Reference 8.3.2-4) (as endorsed by RG 1.129 (Reference 8.3.2-9)) and IEEE Std 384 (Reference 8.3.1-1) (as endorsed by RG 1.75 (Reference 8.3.1-2)).

  Regulatory position C.2 – The Class 1E battery rooms are protected against fires and explosions in accordance with the guidance provided in RG 1.189 (Reference 8.3.2-10) for battery room. The battery rooms, including all penetrations and openings, of redundant trains are separated by minimum 3-hour rated fire barriers. DC switchgear, switchboards, MCCs, UPS or inverters are not located in the Class 1E battery rooms. The Class 1E battery rooms are provided with automatic fire detection systems with provision for local alarm and alarm and annunciation in the MCR. The Class 1E battery room ventilation systems are designed to maintain a hydrogen concentration of less than 1%, and loss of ventilation is alarmed in the MCR. Standpipes and hose stations are readily available outside the Class 1E battery rooms. Portable extinguishers are provided in the Class 1E battery rooms.

  Regulatory position C.3 – The Class 1E batteries of redundant trains are located in separate safety class structures conforming to the requirements of IEEE Std 384 (Reference 8.3.1-1) and RG 1.189 (Reference 8.3.2-10).

  Regulatory position C.4 – The Class 1E batteries are installed on seismic category I racks and their arrangement on the racks provides the ability for cell plate inspection.

<u>Regulatory position C.5</u> – The Class 1E batteries and their installation including racks and anchors are designed and qualified as seismic category I in accordance with IEEE Std 344 (Reference 8.3.1-12) as endorsed by RG 1.100 (Reference 8.3.2-8). The installation is able to withstand the forces of a safe shutdown earthquake event while maintaining battery service during and following the event.

<u>Regulatory position C.6</u> – The Class 1E battery room ventilation systems are designed to limit hydrogen accumulation to 1% of the total volume of the battery room.

<u>Regulatory position C.7</u> – For maintenance and test measurements of Class 1E batteries, pilot cell is not determined by any sampling process. Pilot cell is representative of the average of the entire battery that is obtained by measurement of each cell's specific gravity and float voltage.

<u>Regulatory position C.8</u> – Upon initial installation of Class 1E batteries, each battery's capability is demonstrated by a performance test or a modified performance test in accordance with IEEE Std 450 (Reference 8.3.2-4) as endorsed by RG 1.129 (Reference 8.3.2-9).

<u>Regulatory position C.9</u> – All activities that pertain to Class 1E batteries are performed in accordance with plant quality assurance program.

<u>Regulatory position C.10</u>

(a) The Class 1E battery rooms are kept clean, dry and well ventilated; and they are provided with adequate space and illumination for inspection, maintenance, testing, and cell/battery replacement.

(b) The Class 1E batteries are protected against natural phenomena, such as earthquake, winds, and flooding, as well as induced phenomena, such as radiation, fire, explosion, missiles, pipe whip, discharging fluids, and carbondioxide discharge.

(c) The design of the portable and stationary water in Class 1E battery rooms precludes any inadvertent spilling of water from these facilities onto the battery itself.

(d) Each Class 1E battery installation includes the following instrumentation and alarms:

1) Voltmeter

2) High and low battery voltage alarm

3) Ground detector

4) Instrumentation to measure current through the battery

5) Ventilation air flow sensor and alarm in the MCR

6) Fire detection sensor, instrumentation and alarm as recommended in RG 1.189 (Reference 8.3.2-10)

(e) When storage is required for Class 1E cells, they are stored indoors in a clean, level, dry, and cool location, avoiding extreme low or high temperatures or localized sources of heat.

(f) Upon completion of a freshening charge, a hydrogen survey is performed to verify hydrogen concentration is less than 1%. This concentration conforms with RG 1.189 (Reference 8.3.2-10).

(g) In addition to the items listed in Section 7 of IEEE Std 484 (Reference 8.3.2-3), records of initial hydrogen survey data are maintained for record purposes and future reference.

- RG 1.129, "Maintenance, Testing, and Replacement of Vented Lead-Acid Storage Batteries for Nuclear Power Plants"

  This regulatory guide endorses IEEE Std 450 (Reference 8.3.2-4) with some exceptions, clarifications and supplementary clauses, as indicated in regulatory positions C.1 through C.8. The IEEE Std 450 (Reference 8.3.2-4) provides information and recommendations concerning the maintenance, testing, and replacement of vented lead-acid batteries used in stationary application. The safety-related battery surveillance program conforms to the requirements of IEEE Std 450 (Reference 8.3.2-4) as endorsed by this regulatory guide. This conformance provides an adequate basis for complying with the requirements set forth in GDC 1, 17, and 18 of Appendix A to 10 CFR Part 50 (Reference 8.1-3), as well as Criterion III of Appendix B to 10 CFR part 50 (Reference 8.3.2-11), as they relate to testing the operability and functional performance of safety-related batteries.

- RG 1.153, "Criteria for Safety Systems"

  This regulatory guide endorses IEEE Std 603 (Reference 8.3.1-4) with some clarifications regarding applicability and use of industry standards referenced in Section 3 of IEEE Std 603 (Reference 8.3.1-4). IEEE Std 603 (Reference 8.3.1-4) provides minimum functional and design requirements for the power, instrumentation, and control portions of safety systems for nuclear power generating stations. The IEEE Std 603 (Reference 8.3.1-4) was reissued in 1998 and this later version of the standard is used to establish the minimum functional and design requirements for the safety-related dc power system. The regulatory positions cited in RG 1.153 (Reference 8.3.1-5) are of clarifying nature and the intent of these regulatory positions is considered in establishing the minimum functional and design requirements for the safety-related dc power system.

- RG 1.155, "Station Blackout"

This regulatory guide provides guidance for complying with 10 CFR 50.63 (Reference 8.2-5). The plant has two AAC power sources of which only one is required to be operational to cope with an SBO event. Power supply to all electrical loads that are required to be operational is restored within one hour from the onset of an SBO event. Under normal plant operating conditions, both safety-related and non safety-related dc power systems derive power from the battery chargers that are fed from the safety-related and non safety-related 480V MCCs. Safety-related and non safety-related batteries will provide power to the dc power system during the first hour of an SBO event. Within one hour of an SBO event, power from one of the AAC sources would be available to the required Class 1E battery charger and that train of the dc system will be powered from the associated battery charger. Hence, for an SBO condition, the batteries are required to be sized to provide their duty cycle current for a period of one hour. In addition, all batteries are sized for the worst case duty cycle requirements for a period of two hours, considering loss of associated battery charger and plant conditions that include normal plant operation, LOOP and coincident LOOP and LOCA.

- RG 1.160, “Monitoring the Effectiveness of Maintenance at Nuclear Power Plants”

  This regulatory guide endorses revision 2 of NUMARC 93-01 with some provisions and clarifications for complying with 10 CFR 50.65 (Reference 8.2-7). Conformance to this regulatory guide is generically addressed in Section 1.9.

- RG 1.182, “Assessing and Managing Risk Before Maintenance Activities at Nuclear Power Plants”

  This regulatory guide endorses section 11 of NUMARC 93-01 (Reference 8.2-6) dated February 11, 2000 with some provisions and clarifications for complying with 10 CFR 50.65(a)(4) (Reference 8.2-7). Conformance to this regulatory guide is generically addressed in Section 1.9.

8.3.2.3 Electrical Power System Calculations and Distribution System Studies for DC System

Load flow, voltage regulation, short circuit studies and equipment sizing studies are performed following guidance provided in IEEE Std 946 (Reference 8.3.2-1) and other referenced IEEE standards.

8.3.2.3.1 Load Flow and Under-/Overvoltage Protection

Load flow studies are performed to evaluate whether an acceptable voltage range is maintained at the equipment terminal under worst case loading conditions. Voltage drop at equipment terminal is also calculated under maximum discharge conditions. As a result, terminal voltage of the equipment satisfies the acceptable voltage range based on IEEE Std 946 (Reference 8.3.2-1).

8.3.2.3.2 Short Circuit Studies

Short circuit studies are performed to determine the magnitude of the prospective currents flowing throughout the power system due to a fault occurrence. The studies are performed to calculate the most severe fault condition. This condition is a short circuit at the output terminal of a circuit breaker in the onsite dc distribution system. There are no continuously operating dc motors connected to the Class 1E dc systems. Hence, the Class 1E dc bus short circuit calculations considered only batteries and battery-charger contributions to the fault. The acceptance criteria are that the calculated maximum short circuit current conforms to applicable breaker capability. Table 8.3.2-3 shows the breakers nominal ratings for dc power system. The COL Applicant is to perform short circuit studies to confirm breaker ratings.

8.3.2.3.3 Equipment Sizing Studies

Table 8.3.2-1 and Table 8.3.2-2 show dc spreadsheet load lists. The dc power system equipment sizing is based on the list. The battery and battery charger sizing are performed in accordance with IEEE Std 485 (Reference 8.3.2-2) and IEEE Std 946 (Reference 8.3.2-1), respectively.

Main dc power system equipment ratings are shown in Table 8.3.2-3.

8.3.2.3.4 Equipment Protection and Coordination Studies

The dc power equipment protection and coordination are performed in a manner similar to the ac power system described in Subsection 8.3.1.3.4.

8.3.2.3.5 Power Quality Limits

Onsite power quality limits are described in Subsection 8.3.1.3.6 which includes considering harmonic contribution from the dc power system (i.e. battery chargers).

8.3.3 Tests and Inspections

All active components of the electrical system are accessible for inspection during plant power generation. The electrical system components like transformers, switchgears, circuit breakers, MCCs, GTGs and their controls are tested in accordance with applicable standards and manufacturer recommendations for the Class 1E and non-Class 1E before plant startup.

The Class 1E electrical power systems are provided with four redundant trains and any one train can be taken out for maintenance and testing during normal power operation without impacting the minimum safety requirements.

- The Class 1E GTGs are periodically inspected and tested per the requirements of IEEE Std 387 (Reference 8.1-1).

- The restoration of AAC power supply within 60 minutes to one of the Class 1E buses from the AAC GTG is verified by test.

- The batteries are periodically inspected and tested per IEEE Std 450 (Reference 8.3.2-4) and IEEE Std 484 (Reference 8.3.2-3).

Underground and inaccessible cables within the scope of the maintenance rule (10 CFR 50.65) are monitored by periodical testing in a manner similar to the medium voltage cables in underground duct banks described in Subsection 8.2.1. The COL Applicant is to provide the cable monitoring program for underground and inaccessible cables within the scope of the maintenance rule.

8.3.4 Combined License Information

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 devise coordination.*

COL 8.3(11) *The COL Applicant is to provide insulation coordination (surge and lightning).*

COL 8.3(12) *The COL Applicant is to provide the cable monitoring program for underground and inaccessible cables with the scope of the maintenance rule (10 CFR 50.65).*

8.3.5 References

8.3.1-1 IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits, IEEE Std 384, 1992.

8.3.1-2 Criteria for Independence of Electrical Safety Systems, Regulatory Guide 1.75 Revision 3, February 2005.

8.3.1-3 Seismic Design Classification, Regulatory Guide 1.29 Revision 4, March 2007.

8.3.1-4 IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations, IEEE Std 603, 1991.

8.3.1-5 Criteria for Safety Systems, Regulatory Guide 1.153 Revision 1, June 1996.

8.3.1-6 IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations, IEEE Std 323, 2003.

8.3.1-7 IEEE Standard Criteria for the Protection of Class 1E Power Systems and Equipment in Nuclear Power Generating Stations, IEEE Std 741, 1997.

8.3.1-8 Adequacy of Station Electric Distribution System Voltage, BTP 8-6, March 2007.

8.3.1-9 IEEE Guide for Motor Protection, IEEE Std C37.96, 2000

8.3.1-10 Guide for Protective Relay Applications to Power Transformers, IEEE Std C37.91, 2000.

8.3.1-11 Thermal Overload Protection for Electric Motors on Motor-Operated Valves, Regulatory Guide 1.106 Revision 1, March 1977.

8.3.1-12 IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations, IEEE Std 344, 2004.

8.3.1-13 Qualification and Test Plan of Class 1E Gas Turbine Generator System, MUAP-07024-P Rev.3 (Proprietary) and MUAP-07024-NP Rev.3 (Non-Proprietary).

8.3.1-14 IEEE Standard for Qualifying Class 1E Electric Cables and Field Splices for Nuclear Power Generating Stations, IEEE Std 383, 2003.

8.3.1-15 Standard for the Installation of Lightning Protection Systems, NFPA 780, 2004

8.3.1-16 Guidelines for Lightning Protection of Nuclear Power Plants, Regulatory Guide 1.204 Revision 0, November 2005.

8.3.1-17 IEEE Standard for Electric Penetration Assemblies in Containment Structures for Nuclear Power Generating Stations, IEEE Std 317, 1983.

8.3.1-18 Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems, Regulatory Guide 1.6 Revision 0, March 1971.

8.3.1-19 Criteria for Power Systems for Nuclear Power Plants, Regulatory Guide 1.32 Revision 3, March 2004.

8.3.1-20 Application of the Single-Failure Criterion to Safety Systems, Regulatory Guide 1.53 Revision 2, November 2003.

8.3.1-21 Station Blackout, Regulatory Guide 1.155 Revision 0, August 1988.

8.3.1-22 Enhancement of Onsite Emergency Diesel Generator Reliability, NUREG/CR-0660, February 1979.

8.3.1-23 Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems, Regulatory Guide 1.47 Revision 0, May 1973.

8.3.1-24 Periodic Testing of Electric Power and Protection Systems, Regulatory Guide 1.118 Revision 3, April 1995.

8.3.1-25 Supplemental Guidance for Bypass and Inoperable Status Indication for Engineered Safety Features Systems, BTP 8-5, March 2007.

8.3.1-26 Electric Penetration Assemblies in Containment Structures for Nuclear Power Plants, Regulatory Guide 1.63 Revision 3, February 1987.

8.3.1-27 U.S. Nuclear Regulatory Commission, Standard Review Plan for the Review of Safety Analysis Report for Nuclear Power Plants, NUREG-0800, March 2007.

8.3.1-28 IEEE Standard Application of the Single-Failure Criterion to Nuclear Power Generating Station Safety Systems, IEEE Std 379, 2000.

8.3.1-29 IEEE Standard Criteria for the Periodic Surveillance Testing of Nuclear Power Generating Station Safety Systems, IEEE Std 338, 1987.

8.3.1-30 IEEE Standard Power Cable Ampacity Table, IEEE Std 835, 1994.

8.3.1-31 Ampacities of Cables Installed in Cable Trays, ICEA P-54-440/NEMA WC-51, 2003.

8.3.1-32 National Electrical Code, NFPA 70, 2005.

8.3.1-33 IEEE Guide for Safety in AC Substation Grounding, IEEE Std 80, 2000.

8.3.1-34 IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System, IEEE Std 81, 1983.

8.3.1-35 IEEE Guide to Grounding During the Installation of Overhead Transmission Line Conductors, IEEE Std 524a, 1993

8.3.1-36 Reporting of Defects and Noncompliance, NRC Regulations Title 10, Code of Federal Regulations, 10 CFR Part 21.

8.3.1-37 Quality Assurance Program Requirements for Nuclear Facility Applications, ASME NQA-1, 1994.

8.3.1-38 Onsite AC Power System Calculation, MUAP-09023-P Rev.0 (Proprietary) and MUAP-09023-NP Rev.0 (Non-Proprietary).

8.3.1-39 IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems, IEEE Std 242, 2001.

8.3.1-40 IEEE Standard for Insulation Coordination—Definitions, Principles, and Rules, IEEE Std 1313.1, 1996.

8.3.1-41 IEEE Guide for the Application of Insulation Coordination, IEEE Std 1313.2, 1999.

8.3.1-42 IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems, IEEE Std 519, 1992.

8.3.1-43 Initial Type Test Result of Class 1E Gas Turbine Generator System, MUAP-10023-P (Proprietary) and MUAP-10023-NP (Non-Proprietary), Rev. 5, December 2012.

8.3.1-44 Gas turbines - Procurement - Part 3: Design requirements, ISO 3977-3, 2004.

8.3.2-1 IEEE Recommended Practice for the Design of dc Auxiliary Power Systems for Generating Stations, IEEE Std 946, 2004.

8.3.2-2 IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications, IEEE Std 485, 1997.

8.3.2-3 IEEE Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications, IEEE Std 484, 2002.

8.3.2-4 IEEE Recommended Practice for Maintenance, Testing and Replacement of Vented Lead-Acid Batteries for Stationary Applications, IEEE Std 450, 2002

8.3.2-5 IEEE Standard for Qualification of Class 1E Lead Storage Batteries for Nuclear Power Generating Stations, IEEE Std 535, 2006.

8.3.2-6 Installation Design and Installation of Vented Lead-Acid Storage Batteries for Nuclear Power Plants, Regulatory Guide 1.128 Revision 2, February 2007.

8.3.2-7 IEEE Guide for Installation, Inspection, and Testing for Class 1E Power, Instrumentation, and Control Equipment at Nuclear Facilities, IEEE Std 336, 2005.

8.3.2-8 Seismic Qualification of Electric and Mechanical Equipment for Nuclear Power Plants, Regulatory Guide 1.100 Revision 2, June 1988.

8.3.2-9 Maintenance, Testing, and Replacement of Vented-Acid Storage Batteries for Nuclear Power Plants, Regulatory Guide 1.129 Revision 2, February 2007.

8.3.2-10 Fire Protection for Nuclear Power Plants, Regulatory Guide 1.189 Revision 1, March 2007.

8.3.2-11 Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants, NRC Regulations Title 10, Code of Federal Regulations, 10 CFR Part 50, Appendix B.

Table 8.3.1-1 Electrical Equipment Ratings - Component Data (Sheet 1 of 3)

Main ac Power System (Nominal Values)

1.	Main Transformer (MT)		
	Quantity	Three single phase units (Besides one spare)	
	MVA rating	1 phase 610MVA (3 phase 1830MVA)	
	Low voltage winding	26kV	
	High voltage winding	The high voltage rating is site specific (COL Applicant to provide)	
2.	Unit Auxiliary Transformers (UATs)	UAT1, 2	UAT3, 4
	Quantity	Two 3 phase, 2 winding units	Two 3 phase, 2 winding units
	MVA rating	72MVA	53MVA
	Low voltage winding	13.8kV	6.9kV
	High voltage winding	26kV	26kV
	On-Load Tap Changer (OLTC)	Provided on high voltage side	Provided on high voltage side
3.	Reserve Auxiliary Transformers (RATs)	RAT1, 2	RAT3, 4
	Quantity	Two 3 phase, 3 winding units (including delta tertiary winding)	Two 3 phase, 3 winding units (including delta tertiary winding)
	MVA rating	72MVA	53MVA
	Low voltage winding	13.8kV	6.9kV
	High voltage winding	(by COL Applicant)	(by COL Applicant)
	On-Load Tap Changer (OLTC)	Provided on high voltage side	Provided on high voltage side
4.	Generator Load Break Switch (GLBS)		
	Rated Voltage	Over 28kV	
	Rated Current	Over 44.4kA	
	Rated Frequency	60Hz	
5.	Isolated Phase Busduct (IPB) – Main Circuit		
	Type	Forced air cooling (Cooling air is cooled by water)	
	Rated voltage	Over 28kV	
	Rated current	Over 44.4kA	
	Rated frequency	60Hz	

Table 8.3.1-1 Electrical Equipment Ratings - Component Data (Sheet 2 of 3)

Main ac Power System (Nominal Values)

6.	Isolated Phase Busduct (IPB) – Branch Circuit			
	Type Rated voltage Rated current Rated frequency	Forced air cooling (Cooling air is cooled by water) Over 28kV Over 5900A 60Hz		
7.	13.8kV Medium Voltage System	Non-Class 1E		
	Switchgear	N1 & N2		
	Type Rated current	Metal Clad 3000A		
	Circuit Breaker			
	Maximum voltage Rated short-circuit current Peak current (C & L crest) Control power	15kV 50kA 130kA 125V dc		
8.	6.9kV Medium Voltage System	Class 1E	Non-Class 1E	Non-Class 1E permanent
	Switchgear	A, B, C & D	N3, N4, N5 & N6	P1 & P2
	Type Rated current	Metal Clad 1200A	Metal Clad 3000A	Metal Clad 2000A
	Circuit Breakers Maximum voltage Rated short-circuit current Peak current (C & L Crest) Control power	 8.25kV 63kA 170kA 125V dc	 8.25kV 63kA 170kA 125V dc	 8.25kV 63kA 170kA 125V dc
9.	Low Voltage System (Load Center)	Class 1E	Non-Class 1E	Non-Class 1E permanent
	Circuit Breaker Type	Air Circuit Breaker	Air Circuit Breaker	Air Circuit Breaker
	Rated short-circuit current Rated current Station service transformer Control Power	65kA 4000A A, B, C & D 2500kVA 125V dc	65kA 4000A N1, N2, N3, N4, N5 & N6 2500kVA 125V dc	65kA 4000A P11, P12, P21 & P22 2500kVA 125V dc
10.	480V ac Motor Control Centers			
	Circuit Breaker Type Rated short circuit current Rated current	MCCB 65kA 1000A		

Table 8.3.1-1 Electrical Equipment Ratings - Component Data (Sheet 3 of 3)

Main ac Power System (Nominal Values)

11.	Gas Turbine Generators	Class 1E	Non-Class 1E AAC
	Rated voltage Rated output	6.9kV 4500kW	6.9kV 4600kW

Table 8.3.1-2 Electrical Equipment Ratings – Voltage and Frequency

Nominal ratings and acceptable variations

Equipment		Nominal Voltage	Nominal Frequency	Acceptable Variations		
				Normal Conditions		Motor Starting conditions
				Voltage	Frequency	Voltage
13.8kV System	Switchgear and Transformers	13.8kV	60 Hz	± 10%	± 5%	-
	Motors	13.2kV	60 Hz	± 10%[1]	± 5%[1]	-20%
6.9kV System	Switchgear and Transformers	6.9kV	60 Hz	± 10%	± 5%	-
	Non-Class 1E Motors	6.6kV	60 Hz	± 10%[1]	± 5%[1]	-20%
	Class 1E Motors	6.6kV	60 Hz	± 10%[1]	± 5%[1]	-20%
480V System	Switchgear and Transformers	480V	60 Hz	± 10%	± 5%	-
	Non-Class 1E Motors	460V	60 Hz	± 10%[1]	± 5%[1]	-20%
	Class 1E Motors	460V	60 Hz	± 10%[1]	± 5%[1]	-25%

Note 1: A combined variation in voltage and frequency of 10 % (sum of absolute values) of the rated values, provided the frequency variation does not exceed ± 5% of 60Hz

Table 8.3.1-3 Electrical Load Distribution - UAT/RAT Loading (Sheet 1 of 6)
Normal Operation

Load	Rated Output of Load [kW]	Load Factor [%]	Efficiency [%]	Power Factor [%]	Input of Load			Quantity Installed	Quantity Operating	UAT 1 RAT 1 13.8kV winding		UAT 2 RAT 2 13.8kV winding		UAT 3 RAT 3 6.9kV winding										UAT 4 RAT 4 6.9kV winding									
										N1 Bus		N2 Bus		A Bus		B Bus		N3 Bus		N4 Bus		P1 Bus		C Bus		D Bus		N5 Bus		N6 Bus		P2 Bus	
					[kW]	[kVAR]	[kVA]			Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]
Reactor Coolant Pump	6200	100	95	85	6527	4046	7679	4	4									1	7679	1	7679							1	7679	1	7679		
[[Circulating Water Pump	4500	90	95	65	4264	4986	6560	8	8	4	26240	4	26240																				]]
Motor Driven Main Feed Water Pump	11000	90	95	85	10422	6461	12262	4	4	2	24524	2	24524																				
Condensate Pump	3500	90	95	85	3316	2057	3902	3	2*											1	3902							1	3902	1	3902		
[[Secondary System Cooling Tower Fan	6800	90	95	85	6443	3994	7580	2	2	1	7580	1	7580																				]]
[[Makeup Water Pump	2300	90	95	85	2179	1352	2564	2	1*											1	2564									1	2564		]]
Turbine Component Cooling Water Pump	600	85	95	85	537	334	632	3	2*									1	632			1	632									1	632
Low Pressure Feed Water Heater Drain Pump	500	90	95	85	474	295	558	3	3									1	558	1	558									1	558		
Auxiliary Building Exhaust Fan	260	90	95	85	247	154	291	3	2*									1	291	1	291							1	291				
[[Customer Equipment	3200kVA	80	100	100	2560	0	2560	2	2	1	2560	1	2560																				]]
Emergency Feed Water Pump	590	73	95	85	454	284	535	2	0																								
Safety Injection Pump	900	95	95	85	900	559	1059	4	0																								
Essential Service Water Pump	720	95	95	85	720	448	848	4	2*					1	848	1	848							1	848	1	848						
Component Cooling Water Pump	610	95	95	85	610	379	718	4	2*					1	718	1	718							1	718	1	718						
Containment Spray/Residual Heat Removal Pump	400	95	95	85	400	249	471	4	0																								
Charging Pump	820	95	95	85	820	509	965	2	1*					1	965											1	965						
Essential Chiller Unit	260	95	95	85	260	162	306	4	4					1	306	1	306							1	306	1	306						
Control Rod Drive Mechanism Cooling Fan	350	95	95	85	350	218	412	2	1*													1	412									1	412
Non-Essential Chiller Unit	930	95	95	85	930	579	1095	4	3*													2	2190									2	2190
[[Blowdown Pump	380	95	95	85	380	238	448	2	1*									1	448									1	448				]]
A Station Service Transformer	2500kVA	80	-	85	1700	1054	2000	1	1					1	2000																		
B Station Service Transformer	2500kVA	80	-	85	1700	1054	2000	1	1							1	2000																
C Station Service Transformer	2500kVA	80	-	85	1700	1054	2000	1	1															1	2000								
D Station Service Transformer	2500kVA	80	-	85	1700	1054	2000	1	1																	1	2000						
P11 Station Service Transformer	2500kVA	90	-	85	1913	1185	2250	1	1													1	2250										
P21 Station Service Transformer	2500kVA	90	-	85	1913	1185	2250	1	1																							1	2250
P12 Station Service Transformer	2500kVA	90	-	85	1913	1185	2250	1	1													1	2250										
P22 Station Service Transformer	2500kVA	90	-	85	1913	1185	2250	1	1																							1	2250
N1 Station Service Transformer	2500kVA	90	-	85	1913	1185	2250	1	1	1	2250																						
N2 Station Service Transformer	2500kVA	90	-	85	1913	1185	2250	1	1			1	2250																				
N3 Station Service Transformer	2500kVA	90	-	85	1913	1185	2250	1	1									1	2250														

Table 8.3.1-3 Electrical Load Distribution - UAT/RAT Loading (Sheet 2 of 6)
Normal Operation

Load	Rated Output of Load [kW]	Load Factor [%]	Efficiency [%]	Power Factor [%]	Input of Load			Quantity Installed	Quantity Operating	UAT 1 RAT 1		UAT 2 RAT 2		UAT 3 RAT 3										UAT 4 RAT 4									
										13.8kV winding		13.8kV winding		6.9kV winding										6.9kV winding									
										N1 Bus		N2 Bus		A Bus		B Bus		N3 Bus		N4 Bus		P1 Bus		C Bus		D Bus		N5 Bus		N6 Bus		P2 Bus	
					[kW]	[kVAR]	[kVA]			Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]
N4 Station Service Transformer	2500kVA	90	-	85	1913	1185	2250	1	1											1	2250												
N5 Station Service Transformer	2500kVA	90	-	85	1913	1185	2250	1	1																			1	2250				
N6 Station Service Transformer	2500kVA	90	-	85	1913	1185	2250	1	1																					1	2250		
[[Total Bus Capacity [kVA]											63154		63154		4837		3872		11858		17244		7734		3872		4837		14570		16953		7734]]
[[Transformer Capacity [kVA]											63154		63154										45545										47966]]

*: The quantity that is necessary for operation of a plant is this number. This number does not match up to a total of the quantity of operation of mentions in a column of each transformer.

Note: The horsepower and equipment ratings are preliminary and typical, and are subject to change during detailed design.

Table 8.3.1-3 Electrical Load Distribution - UAT/RAT Loading (Sheet 3 of 6)
Start-up/Shutdown

Load	Rated Output of Load [kW]	Load Factor [%]	Efficiency [%]	Power Factor [%]	Input of Load			Quantity Installed	Quantity Operating	UAT 1 RAT 1		UAT 2 RAT 2		UAT 3 RAT 3										UAT 4 RAT 4									
										13.8kV winding		13.8kV winding		6.9kV winding										6.9kV winding									
										N1 Bus		N2 Bus		A Bus		B Bus		N3 Bus		N4 Bus		P1 Bus		C Bus		D Bus		N5 Bus		N6 Bus		P2 Bus	
					[kW]	[kVAR]	[kVA]			Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]
Reactor Coolant Pump	7800	100	95	85	8211	5089	9660	4	4									1	9660	1	9660							1	9660	1	9660		
[[Circulating Water Pump	4500	90	95	65	4264	4986	6560	8	8	4	26240	4	26240																				]]
Motor Driven Main Feed Water Pump	11000	90	95	85	10422	6461	12262	4	4	2	24524	2	24524																				
Condensate Pump	3500	90	95	85	3316	2057	3902	3	1*											1	3902									1	3902		
[[Secondary System Cooling Tower Fan	6800	90	95	85	6443	3994	7580	2	2	1	7580	1	7580																				]]
[[Makeup Water Pump	2300	90	95	85	2179	1352	2564	2	1*											1	2564									1	2564		]]
Turbine Component Cooling Water Pump	600	85	95	85	537	334	632	3	2*									1	632			1	632									1	632
Low Pressure Feed Water Heater Drain Pump	500	90	95	85	474	295	558	3	3									1	558	1	558									1	558		
Auxiliary Building Exhaust Fan	260	90	95	85	247	154	291	3	2*									1	291	1	291							1	291				
[[Customer Equipment	3200kVA	80	100	100	2560	0	2560	2	2	1	2560	1	2560																				]]
Emergency Feed Water Pump	590	73	95	85	454	284	535	2	0																								
Safety Injection Pump	900	95	95	85	900	559	1059	4	0																								
Essential Service Water Pump	720	95	95	85	720	448	848	4	4					1	848	1	848							1	848	1	848						
Component Cooling Water Pump	610	95	95	85	610	379	718	4	4					1	718	1	718							1	718	1	718						
Containment Spray/Residual Heat Removal Pump	400	95	95	85	400	249	471	4	0																								
Charging Pump	820	95	95	85	820	509	965	2	2					1	965											1	965						
Essential Chiller Unit	260	95	95	85	260	162	306	4	4					1	306	1	306							1	306	1	306						
Control Rod Drive Mechanism Cooling Fan	350	95	95	85	350	218	412	2	1*													1	412									1	412
Non-Essential Chiller Unit	930	95	95	85	930	579	1095	4	3*													2	2190									2	2190
[[Blowdown Pump	380	95	95	85	380	238	448	2	1*									1	448									1	448				]]
A Station Service Transformer	2500kVA	80	-	85	1700	1054	2000	1	1					1	2000																		
B Station Service Transformer	2500kVA	80	-	85	1700	1054	2000	1	1							1	2000																
C Station Service Transformer	2500kVA	80	-	85	1700	1054	2000	1	1															1	2000								
D Station Service Transformer	2500kVA	80	-	85	1700	1054	2000	1	1																	1	2000						
P11 Station Service Transformer	2500kVA	90	-	85	1913	1185	2250	1	1													1	2250										
P21 Station Service Transformer	2500kVA	90	-	85	1913	1185	2250	1	1																							1	2250
P12 Station Service Transformer	2500kVA	90	-	85	1913	1185	2250	1	1													1	2250										
P22 Station Service Transformer	2500kVA	90	-	85	1913	1185	2250	1	1																							1	2250
N1 Station Service Transformer	2500kVA	90	-	85	1913	1185	2250	1	1	1	2250																						
N2 Station Service Transformer	2500kVA	90	-	85	1913	1185	2250	1	1			1	2250																				
N3 Station Service Transformer	2500kVA	90	-	85	1913	1185	2250	1	1									1	2250														
N4 Station Service Transformer	2500kVA	90	-	85	1913	1185	2250	1	1											1	2250												

Table 8.3.1-3 Electrical Load Distribution - UAT/RAT Loading (Sheet 4 of 6)
Start-up/Shutdown

Load	Rated Output of Load [kW]	Load Factor [%]	Efficiency [%]	Power Factor [%]	Input of Load			Quantity Installed	Quantity Operating	UAT 1 RAT 1		UAT 2 RAT 2		UAT 3 RAT 3										UAT 4 RAT 4									
										13.8kV winding		13.8kV winding		6.9kV winding										6.9kV winding									
										N1 Bus		N2 Bus		A Bus		B Bus		N3 Bus		N4 Bus		P1 Bus		C Bus		D Bus		N5 Bus		N6 Bus		P2 Bus	
					[kW]	[kVAR]	[kVA]			Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]
N5 Station Service Transformer	2500kVA	90	-	85	1913	1185	2250	1	1																			1	2250				
N6 Station Service Transformer	2500kVA	90	-	85	1913	1185	2250	1	1																					1	2250		
[[Total Bus Capacity [kVA]											63154		63154		4837		3872		13839		19225		7734		3872		4837		12649		18934		7734]]
[[Transformer Capacity [kVA]											63154		63154										49507										48026]]

*: The quantity that is necessary for operation of a plant is this number. This number does not match up to a total of the quantity of operation of mentions in a column of each transformer.

Note: The horsepower and equipment ratings are preliminary and typical, and are subject to change during detailed design.

Table 8.3.1-3 Electrical Load Distribution - UAT/RAT Loading (Sheet 5 of 6)
Steam Generator Tube Rupture

Load	Rated Output of Load [kW]	Load Factor [%]	Efficiency [%]	Power Factor [%]	Input of Load			Quantity Installed	Quantity Operating	UAT 1 RAT 1 13.8kV winding		UAT 2 RAT 2 13.8kV winding		UAT 3 RAT 3 6.9kV winding										UAT 4 RAT 4 6.9kV winding									
										N1 Bus		N2 Bus		A Bus		B Bus		N3 Bus		N4 Bus		P1 Bus		C Bus		D Bus		N5 Bus		N6 Bus		P2 Bus	
					[kW]	[kVAR]	[kVA]			Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]
Reactor Coolant Pump	6200	100	95	85	6527	4046	7679	4	3*									1	7679	1	7679							1	7679	1	7679		
[[Circulating Water Pump	4500	90	95	65	4264	4986	6560	8	8	4	26240	4	26240																				]]
Motor Driven Main Feed Water Pump	11000	90	95	85	10422	6461	12262	4	0																								
Condensate Pump	3500	90	95	85	3316	2057	3902	3	2*											1	3902							1	3902	1	3902		
[[Secondary System Cooling Tower Fan	6800	90	95	85	6443	3994	7580	2	2	1	7580	1	7580																				]]
[[Makeup Water Pump	2300	90	95	85	2179	1352	2564	2	1*											1	2564									1	2564		]]
Turbine Component Cooling Water Pump	600	85	95	85	537	334	632	3	2*									1	632			1	632									1	632
Low Pressure Feed Water Heater Drain Pump	500	90	95	85	474	295	558	3	0																								
Auxiliary Building Exhaust Fan	260	90	95	85	247	154	291	3	2*									1	291	1	291							1	291				
[[Customer Equipment	3200kVA	80	100	100	2560	0	2560	2	2	1	2560	1	2560																				]]
Emergency Feed Water Pump	590	73	95	85	454	284	535	2	2							1	535							1	535								
Safety Injection Pump	900	95	95	85	900	559	1059	4	4					1	1059	1	1059							1	1059	1	1059						
Essential Service Water Pump	720	95	95	85	720	448	848	4	4					1	848	1	848							1	848	1	848						
Component Cooling Water Pump	610	95	95	85	610	379	718	4	4					1	718	1	718							1	718	1	718						
Containment Spray/Residual Heat Removal Pump	400	95	95	85	400	249	471	4	4					1	471	1	471							1	471	1	471						
Charging Pump	820	95	95	85	820	509	965	2	0																								
Essential Chiller Unit	260	95	95	85	260	162	306	4	4					1	306	1	306							1	306	1	306						
Control Rod Drive Mechanism Cooling Fan	350	95	95	85	350	218	412	2	0																								
Non-Essential Chiller Unit	930	95	95	85	930	579	1095	4	2													1	1095									1	1095
[[Blowdown Pump	380	95	95	85	380	238	448	2	1*									1	448									1	448				]]
A Station Service Transformer	2500kVA	80	-	85	1700	1054	2000	1	1					1	2000																		
B Station Service Transformer	2500kVA	80	-	85	1700	1054	2000	1	1							1	2000																
C Station Service Transformer	2500kVA	80	-	85	1700	1054	2000	1	1															1	2000								
D Station Service Transformer	2500kVA	80	-	85	1700	1054	2000	1	1																	1	2000						
P11 Station Service Transformer	2500kVA	90	-	85	1913	1185	2250	1	1													1	2250										
P21 Station Service Transformer	2500kVA	90	-	85	1913	1185	2250	1	1																							1	2250
P12 Station Service Transformer	2500kVA	90	-	85	1913	1185	2250	1	1													1	2250										
P22 Station Service Transformer	2500kVA	90	-	85	1913	1185	2250	1	1																							1	2250
N1 Station Service Transformer	2500kVA	90	-	85	1913	1185	2250	1	1	1	2250																						
N2 Station Service Transformer	2500kVA	90	-	85	1913	1185	2250	1	1			1	2250																				
N3 Station Service Transformer	2500kVA	90	-	85	1913	1185	2250	1	1									1	2250														

Table 8.3.1-3 Electrical Load Distribution - UAT/RAT Loading (Sheet 6 of 6)
Steam Generator Tube Rupture

Load	Rated Output of Load [kW]	Load Factor [%]	Efficiency [%]	Power Factor [%]	Input of Load			Quantity Installed	Quantity Operating	UAT 1 RAT 1		UAT 2 RAT 2		UAT 3 RAT 3										UAT 4 RAT 4									
										13.8kV winding		13.8kV winding		6.9kV winding										6.9kV winding									
										N1 Bus		N2 Bus		A Bus		B Bus		N3 Bus		N4 Bus		P1 Bus		C Bus		D Bus		N5 Bus		N6 Bus		P2 Bus	
					[kW]	[kVAR]	[kVA]			Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]	Q	[kVA]
N4 Station Service Transformer	2500kVA	90	-	85	1913	1185	2250	1	1											1	2250												
N5 Station Service Transformer	2500kVA	90	-	85	1913	1185	2250	1	1																			1	2250				
N6 Station Service Transformer	2500kVA	90	-	85	1913	1185	2250	1	1																					1	2250		
[[Total Bus Capacity [kVA]											38630		38630		5402		5937		11300		16686		6227		5937		5402		14570		16395		6227]]
[[Transformer Capacity [kVA]											38630		38630										45552										48531]]

*: The quantity that is necessary for operation of a plant is this number. This number does not match up to a total of the quantity of operation of mentions in a column of each transformer.

Note: The horsepower and equipment ratings are preliminary and typical, and are subject to change during detailed design.

Table 8.3.1-4 Electrical Load Distribution - Class 1E GTG Loading (Sheet 1 of 4)
A Class 1E GTG

Load	Quantity Installed	Rated Output [kW]	Load Input [kW]	Efficiency [%]	Power Factor [%]	Load Factor [%]	LOCA Concurrent with a LOOP				LOOP							
											Hot Shutdown				Cold Shutdown			
							Quantity	[kW]	[kVAR]	[kVA]	Quantity	[kW]	[kVAR]	[kVA]	Quantity	[kW]	[kVAR]	[kVA]
A Safety Injection Pump	1	900	900	95	85	95	1	900	558	1059	0	-	-	-	0	-	-	-
A Component Cooling Water Pump	1	610	610	95	85	95	1	610	378	718	1	610	378	718	1	610	378	718
A Essential Service Water Pump	1	720	720	95	85	95	1	720	446	847	1	720	446	847	1	720	446	847
A Containment Spray/Residual Heat Removal Pump	1	400	400	95	85	95	1	400	248	471	0	-	-	-	1	400	248	471
A Charging Pump	1	820	820	95	85	95	0	-	-	-	1	820	508	965	1	820	508	965
A Essential Chiller Unit	1	260	260	95	85	95	1	260	161	306	1	260	161	306	1	260	161	306
A Spent Fuel Pit Pump	1	230	243	90	80	95	0	-	-	-	1	(243)	(182)	(303)	1	(243)	(182)	(303)
A Class 1E Electrical Room Air Handling Unit Electrical Heater	1	120	120	100	100	100	0	-	-	-	0	-	-	-	0	-	-	-
A Pressurizer Heater (Back-up)	1	562	562	100	100	100	0	-	-	-	1	562	0	562	0	-	-	-
Motor Control Centers (A&A1)	2						2	700	158	718	2	660	150	677	2	660	150	677
Total								3590	1949	4085		3632	1643	3986		3470	1891	3952

( ):This load is started by manually if GTG has necessary margin after completing automatic load sequence.

Table 8.3.1-4 Electrical Load Distribution - Class 1E GTG Loading (Sheet 2 of 4)
B Class 1E GTG

Load	Quantity Installed	Rated Output	Load Input	Efficiency	Power Factor	Load Factor	LOCA Concurrent with a LOOP				LOOP							
											Hot Shutdown				Cold Shutdown			
		[kW]	[kW]	[%]	[%]	[%]	Quantity	[kW]	[kVAR]	[kVA]	Quantity	[kW]	[kVAR]	[kVA]	Quantity	[kW]	[kVAR]	[kVA]
B Safety Injection Pump	1	900	900	95	85	95	1	900	558	1059	0	-	-	-	0	-	-	-
B Component Cooling Water Pump	1	610	610	95	85	95	1	610	378	718	1	610	378	718	1	610	378	718
B Essential Service Water Pump	1	720	720	95	85	95	1	720	446	847	1	720	446	847	1	720	446	847
B Containment Spray/Residual Heat Removal Pump	1	400	400	95	85	95	1	400	248	471	0	-	-	-	1	400	248	471
B Emergency Feed Water Pump	1	590	453	95	85	73	1	453	281	533	1	453	281	533	0	-	-	-
B Essential Chiller Unit	1	260	260	95	85	95	1	260	161	306	1	260	161	306	1	260	161	306
A Spent Fuel Pit Pump	1	230	243	90	80	95	0	-	-	-	1	(243)	(182)	(303)	1	(243)	(182)	(303)
B Class 1E Electrical Room Air Handling Unit Electrical Heater	1	120	120	100	100	100	0	-	-	-	0	-	-	-	0	-	-	-
B Pressurizer Heater (Back-up)	1	562	562	100	100	100	0	-	-	-	1	562	0	562	0	-	-	-
Motor Control Centers (B&A1)	2						2	690	139	704	2	650	131	663	2	650	131	663
Total								4033	2211	4599		3255	1397	3542		2640	1364	2972

( ): This load is started by manually if GTG has necessary margin after completing automatic load sequence.

Table 8.3.1-4 Electrical Load Distribution - Class 1E GTG Loading (Sheet 3 of 4)
C Class 1E GTG

Load	Quantity Installed	Rated Output [kW]	Load Input [kW]	Efficiency [%]	Power Factor [%]	Load Factor [%]	LOCA Concurrent with a LOOP				LOOP							
											Hot Shutdown				Cold Shutdown			
							Quantity	[kW]	[kVAR]	[kVA]	Quantity	[kW]	[kVAR]	[kVA]	Quantity	[kW]	[kVAR]	[kVA]
C Safety Injection Pump	1	900	900	95	85	95	1	900	558	1059	0	-	-	-	0	-	-	-
C Component Cooling Water Pump	1	610	610	95	85	95	1	610	378	718	1	610	378	718	1	610	378	718
C Essential Service Water Pump	1	720	720	95	85	95	1	720	446	847	1	720	446	847	1	720	446	847
C Containment Spray/Residual Heat Removal Pump	1	400	400	95	85	95	1	400	248	471	0	-	-	-	1	400	248	471
C Emergency Feed Water Pump	1	590	453	95	85	73	1	453	281	533	1	453	281	533	0	-	-	-
C Class 1E Electrical Room Air Handling Unit Fan	1	110	116	90	80	95	1	116	87	145	1	116	87	145	1	116	87	145
C Essential Chiller Unit	1	260	260	95	85	95	1	260	161	306	1	260	161	306	1	260	161	306
B Spent Fuel Pit Pump	1	230	243	90	80	95	0	-	-	-	1	(243)	(182)	(303)	1	(243)	(182)	(303)
C Class 1E Electrical Room Air Handling Unit Electrical Heater	1	160	160	100	100	100	0	-	-	-	0	-	-	-	0	-	-	-
C Pressurizer Heater (Back-up)	1	562	562	100	100	100	0	-	-	-	1	562	0	562	0	-	-	-
Motor Control Centers (C&D1)	2						2	610	64	613	2	570	56	573	2	570	56	573
Total								4069	2223	4637		3291	1409	3580		2676	1376	3009

( ):This load is started by manually if GTG has necessary margin after completing automatic load sequence.

Table 8.3.1-4 Electrical Load Distribution - Class 1E GTG Loading (Sheet 4 of 4)
D Class 1E GTG

Load	Quantity Installed	Rated Output [kW]	Load Input [kW]	Efficiency [%]	Power Factor [%]	Load Factor [%]	LOCA Concurrent with a LOOP				LOOP Hot Shutdown				LOOP Cold Shutdown			
							Quantity	[kW]	[kVAR]	[kVA]	Quantity	[kW]	[kVAR]	[kVA]	Quantity	[kW]	[kVAR]	[kVA]
D Safety Injection Pump	1	900	900	95	85	95	1	900	558	1059	0	-	-	-	0	-	-	-
D Component Cooling Water Pump	1	610	610	95	85	95	1	610	378	718	1	610	378	718	1	610	378	718
D Essential Service Water Pump	1	720	720	95	85	95	1	720	446	847	1	720	446	847	1	720	446	847
D Containment Spray/Residual Heat Removal Pump	1	400	400	95	85	95	1	400	248	471	0	-	-	-	1	400	248	471
B Charging Pump	1	820	820	95	85	95	0	-	-	-	1	820	508	965	1	820	508	965
D Class 1E Electrical Room Air Handling Unit Fan	1	110	116	90	80	95	1	116	87	145	1	116	87	145	1	116	87	145
D Essential Chiller Unit	1	260	260	95	85	95	1	260	161	306	1	260	161	306	1	260	161	306
B Spent Fuel Pit Pump	1	230	243	90	80	95	0	-	-	-	1	(243)	(182)	(303)	1	(243)	(182)	(303)
D Class 1E Electrical Room Air Handling Unit Electrical Heater	1	160	160	100	100	100	0	-	-	-	0	-	-	-	0	-	-	-
D Pressurizer Heater (Back-up)	1	562	562	100	100	100	0	-	-	-	1	562	0	562	0	-	-	-
Motor Control Centers (D&D1)	2						2	620	99	628	2	580	92	587	2	580	92	587
Total								3626	1977	4130		3668	1672	4031		3506	1920	3997

( ): This load is started by manually if GTG has necessary margin after completing automatic load sequence.

Table 8.3.1-5 Electrical Load Distribution - AAC GTG Loading (LOOP Condition) (Sheet 1 of 2)

A-AAC GTG

Load	Quantity Installed	Rated Output [kW]	Load Input [kW]	Efficiency [%]	Power Factor [%]	Load Factor [%]	LOOP Hot Shutdown Quantity	LOOP Hot Shutdown [kW]	LOOP Hot Shutdown [kVAR]	LOOP Hot Shutdown [kVA]	LOOP Cold Shutdown Quantity	LOOP Cold Shutdown [kW]	LOOP Cold Shutdown [kVAR]	LOOP Cold Shutdown [kVA]
Turbine Component Cooling Water Pump	1	600	537	95	85	85	1	537	333	632	1	537	333	632
Control Rod Drive Mechanism Cooling Fan	1	350	350	95	85	95	1	350	217	412	1	350	217	412
Non-Essential Chiller Unit	2	930	930	95	85	95	1	930	576	1094	1	930	576	1094
Reactor Cavity Cooling Fan	1	160	169	90	80	95	1	169	127	211	1	169	127	211
Turning Oil Pump	1	200	211	90	80	95	1	211	158	264	1	211	158	264
Instrument Air Compressor	1	150	158	90	80	95	1	158	119	198	1	158	119	198
Turbine Building Electrical Room Duct Heater	1	405	405	100	100	100	0	0	0	0	0	0	0	0
Turbine Building Electrical Room Air Handling Unit	1	450	202	90	80	40	1	202	151	252	1	202	151	252
Non-Essential Chilled Water System Cooling Tower Pump	2	190	201	90	80	95	1	201	150	251	1	201	150	251
Motor Control Centers (P11&P12)	2						2	1150	863	1438	2	1150	863	1438
AAC Supporting Equipment	1						1	80	60	100	1	80	60	100
AAC Motor Control Center	1						1	170	128	213	1	170	128	213
Total								4158	2882	5059		4158	2882	5059

Table 8.3.1-5 Electrical Load Distribution - AAC GTG Loading (LOOP Condition) (Sheet 2 of 2)

B-AAC GTG

Load	Quantity Installed	Rated Output [kW]	Load Input [kW]	Efficiency [%]	Power Factor [%]	Load Factor [%]	LOOP							
							Hot Shutdown				Cold Shutdown			
							Quantity	[kW]	[kVAR]	[kVA]	Quantity	[kW]	[kVAR]	[kVA]
Turbine Component Cooling Water Pump	1	600	537	95	85	85	1	537	333	632	1	537	333	632
Control Rod Drive Mechanism Cooling Fan	1	350	350	95	85	95	1	350	217	412	1	350	217	412
Non-Essential Chiller Unit	2	930	930	95	85	95	1	930	576	1094	1	930	576	1094
Reactor Cavity Cooling Fan	1	160	169	90	80	95	1	169	127	211	1	169	127	211
Instrument Air Compressor	1	150	158	90	80	95	1	158	119	198	1	158	119	198
Turbine Building Electrical Room Duct Heater	1	405	405	100	100	100	0	0	0	0	0	0	0	0
Turbine Building Electrical Room Air Handling Unit	1	450	202	90	80	40	1	202	151	252	1	202	151	252
Non-Essential Chilled Water System Cooling Tower Pump	2	190	201	90	80	95	1	201	150	251	1	201	150	251
Motor Control Centers (P21&P22)	2						2	1080	810	1350	2	1080	810	1350
AAC Supporting Equipment	1						1	80	60	100	1	80	60	100
AAC Motor Control Center	1						1	170	128	213	1	170	128	213
Total								3877	2671	4708		3877	2671	4708

Table 8.3.1-6 Electrical Load Distribution - AAC GTG Loading (SBO Condition)

AAC GTG

Bus	Load	Quantity Installed	Rated Output [kW]	Load Input [kW]	Efficiency [%]	Power Factor [%]	Load Factor [%]	SBO							
								Hot Standby				Cold Shutdown			
								A or B AAC GTG				A and B AAC GTG			
								Quantity	[kW]	[kVAR]	[kVA]	Quantity	[kW]	[kVAR]	[kVA]
Class 1E Bus	Component Cooling Water Pump	1	610	610	95	85	95	1	610	378	718	1	610	378	718
	Essential Service Water Pump	1	720	720	95	85	95	1	720	446	847	1	720	446	847
	Containment Spray/Residual Heat Removal Pump	1	400	400	95	85	95	0	-	-	-	1	400	248	471
	Charging Pump	1	820	820	95	85	95	1	820	508	965	1	820	508	965
	Class 1E Electrical Room Air Handling Unit Fan	1	110	116	90	80	95	1	116	87	145	1	116	87	145
	Essential Chiller Unit	1	260	260	95	85	95	1	260	161	306	1	260	161	306
	Class 1E Electrical Room Air Handling Unit Electrical Heater	1	160	160	100	100	100	0	-	-	-	0	-	-	-
	Pressurizer Heater	1	562	562	100	100	100	0	-	-	-	0	-	-	-
	Motor Control Center	2						2	660	150	677	2	660	150	677
	Subtotal								3186	1730	3625		3586	1978	4095
	AAC Motor Control Center								170	128	213		170	128	213
	AAC Supporting equipment								80	60	100		80	60	100
Total									3436	1918	3935		3836	2166	4405

Table 8.3.1-7 Electrical Load Distribution - Class 1E MCC Loads (Sheet 1 of 4)

A-MCC and A1-MCC

A-Motor Control Center		
Name	**Rated Output [kW]**	
A-Class 1E Gas Turbine Generator Auxiliary Panel	68	
A-Emergency Feed Water Pump (T/D) Area Air Handling Unit	8.5	
A-Essential Chiller Unit Control Panel	2	kVA
A-Essential Chilled Water Pump	53	
A-UPS Unit	50	kVA
A-I&C Power Transformer	50	kVA
A-Main Control Room Air Handling Unit	13	
A-Main Control Room Electrical Reheating Coil	46	
A-Safeguard Component Area Air Handling Unit	9	
A-Class 1E Battery Room Exhaust Fan	1.5	
A-Battery Charger	125	kVA
A-Safety Injection Pump Auxiliary Oil Pump	1.5	
A-Class 1E I&C Room Electrical Reheating Coil	12	
A-Emergency Feed Water Pump (T/D) Area Electric Heater	8.5	
A-Emergency Lighting Transformer	10	kVA

A1-Motor Control Center		
Name	**Rated Output [kW]**	
A-Annulus Emergency Exhaust Filtration Unit Fan	13	
A-Annulus Emergency Exhaust Filtration Unit Electric Heating Coil	27	
A-Main Control Room Emergency Filtration Unit Fan	5.5	
A-Main Control Room Emergency Filtration Unit Electric Heating Coil	18	
A-Remote Shutdown Console Room Electrical Reheating Coil	10	

Note: This table doesn't show MOVs and all loads.

Table 8.3.1-7 Electrical Load Distribution - Class 1E MCC Loads (Sheet 2 of 4)

B-MCC

B-Motor Control Center		
Name	**Rated Output [kW]**	
B-Class 1E Gas Turbine Generator Auxiliary Panel	68	
B-Emergency Feed Water Pump (M/D) Area Air Handling Unit	8.5	
B-Essential Chiller Unit Control Panel	2	kVA
B-Essential Chilled Water Pump	53	
B-UPS Unit	50	kVA
B-I&C Power Transformer	50	kVA
B-Main Control Room Air Handling Unit	13	
B-Main Control Room Electrical Reheating Coil	46	
B-Safeguard Component Area Air Handling Unit	9	
B-Class 1E Battery Room Exhaust Fan	1.5	
B-Battery Charger	125	kVA
B-Safety Injection Pump Auxiliary Oil Pump	1.5	
B-Class 1E I&C Room Electrical Reheating Coil	12	
B-Emergency Feed Water Pump (M/D) Area Electric Heater	8.5	
B-Emergency Lighting Transformer	10	kVA

Note: This table doesn't show MOVs and all loads.

Table 8.3.1-7 Electrical Load Distribution - Class 1E MCC Loads (Sheet 3 of 4)

C-MCC

C-Motor Control Center		
Name	**Rated Output [kW]**	
C-Class 1E Gas Turbine Generator Auxiliary Panel	68	
C-Emergency Feed Water Pump (M/D) Area Air Handling Unit	8.5	
C-Essential Chiller Unit Control Panel	2	kVA
C-Essential Chilled Water Pump	53	
C-UPS Unit	50	kVA
C-I&C Power Transformer	50	kVA
C-Main Control Room Air Handling Unit	13	
C-Main Control Room Electrical Reheating Coil	46	
C-Safeguard Component Area Air Handling Unit	9	
C-Class 1E Battery Room Exhaust Fan	1.5	
C-Battery Charger	125	kVA
C-Safety Injection Pump Auxiliary Oil Pump	1.5	
C-Class 1E I&C Room Electrical Reheating Coil	12	
C-Emergency Feed Water Pump (M/D) Area Electric Heater	8.5	
C- Emergency Lighting Transformer	10	kVA

Note: This table doesn't show MOVs and all loads.

Table 8.3.1-7 Electrical Load Distribution - Class 1E MCC Loads (Sheet 4 of 4)

D-MCC and D1-MCC

D-Motor Control Center		
Name	**Rated Output [kW]**	
D-Class 1E Gas Turbine Generator Auxiliary Panel	68	
D-Emergency Feed Water Pump (T/D) Area Air Handling Unit	8.5	
D-Essential Chiller Unit Control Panel	2	kVA
D-Essential Chilled Water Pump	53	
D-UPS Unit	50	kVA
D-I&C Power Transformer	50	kVA
D-Main Control Room Air Handling Unit	13	
D-Main Control Room Electrical Reheating Coil	46	
D-Safeguard Component Area Air Handling Unit	9	
D-Class 1E Battery Room Exhaust Fan	1.5	
D-Battery Charger	125	kVA
D-Safety Injection Pump Auxiliary Oil Pump	1.5	
D-Class 1E I&C Room Electrical Reheating Coil	12	
D-Emergency Feed Water Pump (T/D) Area Electric Heater	8.5	
D-Emergency Lighting Transformer	10	kVA
D1-Motor Control Center		
Name	**Rated Output [kW]**	
B-Annulus Emergency Exhaust Filtration Unit Fan	13	
B-Annulus Emergency Exhaust Filtration Unit Electric Heating Coil	27	
B-Main Control Room Emergency Filtration Unit Fan	5.5	
B-Main Control Room Emergency Filtration Unit Electric Heating Coil	18	
B-Remote Shutdown Console Room Electrical Reheating Coil	10	

Note: This table doesn't show MOVs and all loads.

Table 8.3.1-8 Class 1E and AAC GTG Alarms

Description	Local	MCR
Engine		
Lubricating oil low pressure	Yes	Yes
Lubricating oil high temperature	Yes	Yes
Starting air low pressure	Yes	Yes
Engine failure to start (after automatic attempt to start)	Yes	Yes
Overspeed	Yes	Yes
Low fuel oil day tank level	Yes	Yes
High fuel oil day tank level	Yes	Yes
Fuel Oil Tank High	Yes	Yes
Fuel Oil Tank Low	Yes	Yes
Governor Not Isochronous	Yes	Yes
Generator		
Generator differential	Yes	Yes
Overcurrent with voltage restraint, ground fault overcurrent (Inst.), reverse power	Yes	Yes
Loss of excitation	Yes	Yes
Stator high temperature	Yes	Yes
Bearing high temperature	Yes	Yes
Field ground fault	Yes	Yes
System status		
Loss of control power supply	Yes	Yes
Loss of 480V ac auxiliary power supply	Yes	Yes
GTG automatic start	Yes	Yes
GTG control-local	Yes	Yes
Any fault or irregularity occurring during the standby (ready to start) and running modes	Yes	Yes

Table 8.3.1-9 Electrical Equipment Location List (Sheet 1 of 6)

Name	Location		
	Bldg/F	Elevation	Room
A-Class 1E 6.9kV Switchgear	R/B 1F	EL 3'-7"	A-Class 1E Electrical Room
A-Class 1E 480V Load Center	R/B 1F	EL 3'-7"	A-Class 1E Electrical Room
A1-Class 1E 480V Load Center	R/B 1F	EL 3'-7"	A-Class 1E Electrical Room
A-Class 1E Motor Control Center	R/B 1F	EL 3'-7"	A-Class 1E Electrical Room
A1-Class 1E Motor Control Center	R/B 1F	EL 3'-7"	A-Class 1E Electrical Room
A-Class 1E MOV Motor Control Center 1	PS/B B1F	EL -26'-4"	A-Class 1E MOV Inverter Room
A-Class 1E MOV Motor Control Center 2	PS/B B1F	EL -26'-4"	A-Class 1E MOV Inverter Room
A-Pressurizer Heater Distribution Panel	R/B 1F	EL 3'-7"	A-Class 1E Electrical Room
B-Class 1E 6.9kV Switchgear	R/B 1F	EL 3'-7"	B-Class 1E Electrical Room
B-Class 1E 480V Load Center	R/B 1F	EL 3'-7"	B-Class 1E Electrical Room
B-Class 1E Motor Control Center	R/B 1F	EL 3'-7"	B-Class 1E Electrical Room
B-Class 1E MOV Motor Control Center	PS/B B1F	EL -26'-4"	B-Class 1E MOV Inverter Room
B-Pressurizer Heater Distribution Panel	R/B 1F	EL 3'-7"	B-Class 1E Electrical Room
A-RCP Trip Switchgear	R/B 1F	EL 3'-7"	B-Class 1E Electrical Room
B-RCP Trip Switchgear	R/B 1F	EL 3'-7"	B-Class 1E Electrical Room
C-Class 1E 6.9kV Switchgear	R/B 1F	EL 3'-7"	C-Class 1E Electrical Room
C-Class 1E 480V Load Center	R/B 1F	EL 3'-7"	C-Class 1E Electrical Room
C-Class 1E Motor Control Center	R/B 1F	EL 3'-7"	C-Class 1E Electrical Room
C-Class 1E MOV Motor Control Center	PS/B B1F	EL -26'-4"	C-Class 1E MOV Inverter Room
C-Pressurizer Heater Distribution Panel	R/B 1F	EL 3'-7"	C-Class 1E Electrical Room
C-RCP Trip Switchgear	R/B 1F	EL 3'-7"	C-Class 1E Electrical Room
D-RCP Trip Switchgear	R/B 1F	EL 3'-7"	C-Class 1E Electrical Room
D-Class 1E 6.9kV Switchgear	R/B 1F	EL 3'-7"	D-Class 1E Electrical Room
D-Class 1E 480V Load Center	R/B 1F	EL 3'-7"	D-Class 1E Electrical Room
D1-Class 1E 480V Load Center	R/B 1F	EL 3'-7"	D-Class 1E Electrical Room
D-Class 1E Motor Control Center	R/B 1F	EL 3'-7"	D-Class 1E Electrical Room

Table 8.3.1-9 Electrical Equipment Location List (Sheet 2 of 6)

Name	Location		
	Bldg/F	Elevation	Room
D1-Class 1E Motor Control Center	R/B 1F	EL 3'-7"	D-Class 1E Electrical Room
D-Class 1E MOV Motor Control Center 1	PS/B B1F	EL -26'-4"	D-Class 1E MOV Inverter Room
D-Class 1E MOV Motor Control Center 2	PS/B B1F	EL -26'-4"	D-Class 1E MOV Inverter Room
D-Pressurizer Heater Distribution Panel	R/B 1F	EL 3'-7"	D-Class 1E Electrical Room
A-Class 1E UPS Unit	R/B 2F	EL 25'-3"	A-Class 1E UPS Room
A-Class 1E MOV Inverter 1	PS/B B1F	EL -26'-4"	A-Class 1E MOV Inverter Room
A-Class 1E MOV Inverter 2	PS/B B1F	EL -26'-4"	A-Class 1E MOV Inverter Room
A-Solenoid Distribution Panel	R/B 1F	EL 3’-7”	A-Class 1E Electrical Room
A-Class 1E AC 120V Panelboard	R/B 1F	EL 3’-7”	A-Class 1E Electrical Room
A1-Class 1E AC120V Panelboard	R/B 1F	EL 3’-7”	A-Class 1E Electrical Room
A2-Class 1E AC120V Panelboard	R/B 1F	EL 3’-7”	A-Class 1E Electrical Room
B-Class 1E UPS Unit	R/B 2F	EL 25'-3"	B-Class 1E UPS Room
B-Class 1E MOV Inverter	PS/B B1F	EL -26'-4"	B-Class 1E MOV Inverter Room
B-Solenoid Distribution Panel	R/B 1F	EL 3’-7”	B-Class 1E Electrical Room
B-Class 1E AC 120V Panelboard	R/B 1F	EL 3’-7”	B-Class 1E Electrical Room
B1-Class 1E AC120V Panelboard	R/B 1F	EL 3’-7”	B-Class 1E Electrical Room
B2-Class 1E AC120V Panelboard	R/B 1F	EL 3’-7”	B-Class 1E Electrical Room
C-Class 1E UPS Unit	R/B 2F	EL 25'-3"	C-Class 1E UPS Room
C-Class 1E MOV Inverter	PS/B B1F	EL -26'-4"	C-Class 1E MOV Inverter Room
C-Solenoid Distribution Panel	R/B 1F	EL 3’-7”	C-Class 1E Electrical Room
C-Class 1E AC120V Panelboard	R/B 1F	EL 3’-7”	C-Class 1E Electrical Room
C1-Class 1E AC120V Panelboard	R/B 1F	EL 3’-7”	C-Class 1E Electrical Room
C2-Class 1E AC120V Panelboard	R/B 1F	EL 3’-7”	C-Class 1E Electrical Room
D-Class 1E UPS Unit	R/B 2F	EL 25'-3"	D-Class 1E UPS Room
D-Class 1E MOV Inverter 1	PS/B B1F	EL -26'-4"	D-Class 1E MOV Inverter Room
D-Class 1E MOV Inverter 2	PS/B B1F	EL -26'-4"	D-Class 1E MOV Inverter Room
D-Solenoid Distribution Panel	R/B 1F	EL 3’-7”	D-Class 1E Electrical Room

Table 8.3.1-9 Electrical Equipment Location List (Sheet 3 of 6)

Name	Location		
	Bldg/F	Elevation	Room
D-Class 1E AC120V Panelboard	R/B 1F	EL 3’-7”	D-Class 1E Electrical Room
D1-Class 1E AC120V Panelboard	R/B 1F	EL 3’-7”	D-Class 1E Electrical Room
D2-Class 1E AC120V Panelboard	R/B 1F	EL 3’-7”	D-Class 1E Electrical Room
A-Class 1E Battery Charger	PS/B B1MF	EL -14’-2”	A-Class 1E Battery Charger Room
A-Class 1E DC Switchboard	PS/B B1MF	EL -14’-2”	A-Class 1E Battery Charger Room
B-Class 1E Battery Charger	PS/B B1MF	EL -14’-2”	B-Class 1E Battery Charger Room
B-Class 1E DC Switchboard	PS/B B1MF	EL -14’-2”	B-Class 1E Battery Charger Room
C-Class 1E Battery Charger	PS/B B1MF	EL -14’-2”	C-Class 1E Battery Charger Room
C-Class 1E DC Switchboard	PS/B B1MF	EL -14’-2”	C-Class 1E Battery Charger Room
D-Class 1E Battery Charger	PS/B B1MF	EL -14’-2”	D-Class 1E Battery Charger Room
D-Class 1E DC Switchboard	PS/B B1MF	EL -14’-2”	D-Class 1E Battery Charger Room
AB Spare Battery Charger	PS/B B1MF	EL -14’-2”	Spare Battery Charger Room-1
CD Spare Battery Charger	PS/B B1MF	EL -14’-2”	Spare Battery Charger Room-2
A-Class 1E Battery	PS/B B1F	EL -26’-4"	A-Class 1E Battery Room
B-Class 1E Battery	PS/B B1F	EL -26’-4"	B-Class 1E Battery Room
C-Class 1E Battery	PS/B B1F	EL -26’-4"	C-Class 1E Battery Room
D-Class 1E Battery	PS/B B1F	EL -26’-4"	D-Class 1E Battery Room
Presserizer Heater Distribution Panel 1	R/B 4F	EL 76'-5"	CRDM Cabinet Room
Presserizer Heater Distribution Panel 2	R/B 4F	EL 76'-5"	CRDM Cabinet Room
P11-Non-Class 1E Motor Control Center	A/B 2F	EL 30'-2"	Non-Class 1E Electrical Room
P21-Non-Class 1E Motor Control Center	A/B 2F	EL 30'-2"	Non-Class 1E Electrical Room
N31-Non-Class 1E Motor Control Center	A/B 2F	EL 30'-2"	Non-Class 1E Electrical Room
N41-Non-Class 1E Motor Control Center	A/B 2F	EL 30'-2"	Non-Class 1E Electrical Room

Table 8.3.1-9 Electrical Equipment Location List (Sheet 4 of 6)

Name	Location		
	Bldg/F	Elevation	Room
N51-Non-Class 1E Motor Control Center	A/B 2F	EL 30'-2"	Non-Class 1E Electrical Room
N61-Non-Class 1E Motor Control Center	A/B 2F	EL 30'-2"	Non-Class 1E Electrical Room
N11-UPS Unit	A/B 2F	EL 30'-2"	Non-Class 1E Electrical Room
N11-Non-Class 1E AC120V Switch Board	A/B 2F	EL 30'-2"	Non-Class 1E Electrical Room
N12-UPS Unit	A/B 2F	EL 30'-2"	Non-Class 1E Electrical Room
N12-Non-Class 1E AC120V Switch Board	A/B 2F	EL 30'-2"	Non-Class 1E Electrical Room
N21-UPS Unit	T/B 1F	EL 3'-7"	Electrical Room
N21-Non-Class 1E AC120V Switch Board	T/B 1F	EL 3'-7"	Electrical Room
N22-UPS Unit	T/B 2F	EL 34'-0"	Electrical Room
N22-Non-Class 1E AC120V Switch Board	T/B 2F	EL 34'-0"	Electrical Room
N31-UPS Unit	A/B 2F	EL 30'-2"	Non-Class 1E Electrical Room
N31-Non-Class 1E AC120V Switch Board	A/B 2F	EL 30'-2"	Non-Class 1E Electrical Room
N32-UPS Unit	A/B 2F	EL 30'-2"	Non-Class 1E Electrical Room
N32-Non-Class 1E AC120V Switch Board	A/B 2F	EL 30'-2"	Non-Class 1E Electrical Room
N41-UPS Unit	A/B 2F	EL 30'-2"	Non-Class 1E Electrical Room
N41-Non-Class 1E AC120V Switch Board	A/B 2F	EL 30'-2"	Non-Class 1E Electrical Room
N42-UPS Unit	A/B 2F	EL 30'-2"	Non-Class 1E Electrical Room
N42-Non-Class 1E AC120V Switch Board	A/B 2F	EL 30'-2"	Non-Class 1E Electrical Room
N5-UPS Unit	A/B 2F	EL 30'-2"	Non-Class 1E Electrical Room
N5-Non-Class 1E AC120V Switch Board	A/B 2F	EL 30'-2"	Non-Class 1E Electrical Room
N1-Non-Class 1E Battery Charger	A/B 2F	EL 30'-2"	Non-Class 1E Electrical Room
N1-Non-Class 1E DC125V Switch Board	A/B 2F	EL 30'-2"	Non-Class 1E Electrical Room
N2-Non-Class 1E Battery Charger	A/B 2F	EL 30'-2"	Non-Class 1E Electrical Room
N2-Non-Class 1E DC125V Switch Board	A/B 2F	EL 30'-2"	Non-Class 1E Electrical Room
N12-Non-Class 1E Battery Charger	A/B 2F	EL 30'-2"	Non-Class 1E Electrical Room
N1-Non-Class 1E Battery	A/B 2F	EL 30'-2"	Non-Class 1E Battery Room
N2-Non-Class 1E Battery	A/B 2F	EL 30'-2"	Non-Class 1E Battery Room

Table 8.3.1-9 Electrical Equipment Location List (Sheet 5 of 6)

Name	Location		
	Bldg/F	Elevation	Room
N1-Non-Class 1E 13.8kV Switchgear	T/B 2F	EL 34'-0"	Electrical Room
N2-Non-Class 1E 13.8kV Switchgear	T/B 1F	EL 3'-7"	Electrical Room
P1-Non-Class 1E 6.9kV Switchgear	T/B 2F	EL 34'-0"	Electrical Room
P2-Non-Class 1E 6.9kV Switchgear	T/B 1F	EL 3'-7"	Electrical Room
N3-Non-Class 1E 6.9kV Switchgear	T/B 2F	EL 34'-0"	Electrical Room
N4-Non-Class 1E 6.9kV Switchgear	T/B 2F	EL 34'-0"	Electrical Room
N5-Non-Class 1E 6.9kV Switchgear	T/B 1F	EL 3'-7"	Electrical Room
N6-Non-Class 1E 6.9kV Switchgear	T/B 1F	EL 3'-7"	Electrical Room
P11-Non-Class 1E 480V Load Center	T/B 2F	EL 34'-0"	Electrical Room
P21-Non-Class 1E 480V Load Center	T/B 1F	EL 3'-7"	Electrical Room
P12-Non-Class 1E 480V Load Center	T/B 2F	EL 34’-0”	Electrical Room
P22-Non-Class 1E 480V Load Center	T/B 1F	EL 3’-7”	Electrical Room
N1-Non-Class 1E 480V Load Center	T/B 2F	EL 34'-0"	Electrical Room
N2-Non-Class 1E 480V Load Center	T/B 1F	EL 3'-7"	Electrical Room
N3-Non-Class 1E 480V Load Center	T/B 2F	EL 34'-0"	Electrical Room
N4-Non-Class 1E 480V Load Center	T/B 2F	EL 34’-0”	Electrical Room
N5-Non-Class 1E 480V Load Center	T/B 1F	EL 3'-7"	Electrical Room
N6-Non-Class 1E 480V Load Center	T/B 1F	EL 3'-7"	Electrical Room
P12-Non-Class 1E Motor Control Center	T/B 1F	EL 3’-7”	Turbine Building Local
P22-Non-Class 1E Motor Control Center	T/B 1F	EL 3'-7"	Turbine Building Local
N1-Non-Class 1E Motor Control Center	T/B 3F	EL 61’-0”	Turbine Building Local
N2-Non-Class 1E Motor Control Center	T/B 3F	EL 61’-0”	Turbine Building Local
N32-Non-Class 1E Motor Control Center	T/B 3F	EL 61’-0”	Turbine Building Local
N42-Non-Class 1E Motor Control Center	T/B 1F	EL 3’-7”	Turbine Building Local
N52-Non-Class 1E Motor Control Center	T/B 3F	EL 61’-0”	Turbine Building Local
N62-Non-Class 1E Motor Control Center	T/B 1F	EL 3'-7"	Turbine Building Local
N3-Non-Class 1E Battery Charger	T/B 2F	EL 34'-0"	Electrical Room

Table 8.3.1-9 Electrical Equipment Location List (Sheet 6 of 6)

Name	Location		
	Bldg/F	Elevation	Room
N3-Non-Class 1E DC125V Switch Board	T/B 2F	EL 34'-0"	Electrical Room
N4-Non-Class 1E Battery Charger	T/B 1F	EL 3'-7"	Electrical Room
N4-Non-Class 1E DC125V Switch Board	T/B 1F	EL 3'-7"	Electrical Room
N34-Non-Class 1E Battery Charger	T/B 2F	EL 34'-0"	Electrical Room
N3-Non-Class 1E Battery	T/B 2F	EL 34'-0"	Electrical Room
N4-Non-Class 1E Battery	T/B 1F	EL 3'-7"	Electrical Room
A-Class 1E GTG	PS/B	EL 3'-7"	A-Class 1E GTG Room
B-Class 1E GTG	PS/B	EL 3'-7"	B-Class 1E GTG Room
C-Class 1E GTG	PS/B	EL 3'-7"	C-Class 1E GTG Room
D-Class 1E GTG	PS/B	EL 3'-7"	D-Class 1E GTG Room
A-AAC GTG	PS/B	EL 3'-7"	A-AAC GTG Room
B-AAC GTG	PS/B	EL 3'-7"	B-AAC GTG Room
A-AAC Selector Circuit Panel	PS/B	EL -14’-2”	A-AAC Selector Circuit Panel Room
A-AAC Motor Control Center	PS/B	EL -14’-2”	A-AAC Selector Circuit Panel Room
B-AAC Selector Circuit Panel	PS/B	EL -14’-2”	B-AAC Selector Circuit Panel Room
B-AAC Motor Control Center	PS/B	EL -14’-2”	B-AAC Selector Circuit Panel Room

Table 8.3.1-10 Motor Operated Valve List

Valves	Quantity	Current
Charging line isolation valve	1	15 A
RCP seal water return line isolation valve	1	7 A
Emergency feed water pump actuation valve	2	25 A
Hot leg sampling line CV isolation valve	2	7 A
Refueling water storage line isolation valve	1	15 A
Instrument air line isolation valve	1	7 A
RCP cooling water line isolation valve	4	45 A
Containment fan cooler unit cooling water line isolation valve	1	45 A
Total		333 A

Note : This table shows list for one train.

Table 8.3.1-11 Electrical Equipment Ratings - Component Data Class 1E I&C Power Source (Nominal Values)

a. UPS Unit	
Rating	: 50kVA
Input nominal voltage	: 3 phase 480V
Input operating voltage range	: 408V to 552 V
Input frequency	: 60Hz +/-10%
DC input voltage	: 125V +/-20%
Nominal output ac voltage	: 120V
Output voltage regulation	: <+/-2%
Output frequency	: 60Hz +/-0.5%
Voltage distortion	: =/<3%
b. Transformer	
Rating	: 50kVA
Input nominal voltage	: single phase 480V
Output nominal voltage	: single phase 120V
Tap	: primary side 440V, 460V, 480V, 500V and 520V

Table 8.3.2-1 125V DC Class 1E Load Current Requirement (Sheet 1 of 4) Train A

Load Description	Normal Current (A)	Maximum Load Current		
		0 to 1 min (A)	1 to 119 min (A)	119 to 120 min (A)
A Switchboard Control Circuit	2	2	2	2
A Class 1E 6.9kV Switchgear	4	100	4	30
A Class 1E 480V Load Center	4	24	4	4
A Class 1E GTG Control Board	1	5	5	5
A UPS Unit	0	263	263	263
A&B MOV Inverter	1	1440	1	1
A Reactor Building DC Distribution Panel	11	15	11	11
A Solenoid Valve Distribution Panel	20	20	20	20
A Battery Charger Control Circuit	2	0	0	0
A Emergency Lighting	10	10	10	10
A MCR Radiation Monitor Pump	30	30	30	30
A Emergency Feedwater Pump Emergency Oil Pump	35	56	0	0
Total	120	1965	350	376
Random Load			For One Minute - 195	195

Table 8.3.2-1 125V DC Class 1E Load Current Requirement (Sheet 2 of 4) Train B

Load Description	Normal Current (A)	Maximum Load Current		
		0 to 1 min (A)	1 to 119 min (A)	119 to 120 min (A)
B Switchboard Control Circuit	2	2	2	2
B Class 1E 6.9kV Switchgear	4	100	4	30
B Class 1E 480V Load Center	4	24	4	4
B Class 1E GTG Control Board	1	5	5	5
B UPS Unit	0	263	263	263
A&B MOV Inverter	1	1440	1	1
B Reactor Building DC Distribution Panel	11	15	11	11
B Solenoid Valve Distribution Panel	20	20	20	20
B Battery Charger Control Circuit	2	0	0	0
B Emergency Lighting	10	10	10	10
A MCR Radiation Monitor Pump	30	30	30	30
Total	85	1909	350	376
Random Load			For One Minute - 195	195

Table 8.3.2-1 125V DC Class 1E Load Current Requirement (Sheet 3 of 4) Train C

Load Description	Normal Current (A)	Maximum Load Current		
		0 to 1 min (A)	1 to 119 min (A)	119 to 120 min (A)
C Switchboard Control Circuit	2	2	2	2
C Class 1E 6.9kV Switchgear	4	100	4	30
C Class 1E 480V Load Center	4	24	4	4
C Class 1E GTG Control Board	1	5	5	5
C UPS Unit	0	263	263	263
C&D MOV Inverter	1	1440	1	1
C Reactor Building DC Distribution Panel	11	15	11	11
C Solenoid Valve Distribution Panel	20	20	20	20
C Battery Charger Control Circuit	2	0	0	0
C Emergency Lighting	10	10	10	10
B MCR Radiation Monitor Pump	30	30	30	30
Total	85	1909	350	376
Random Load			For One Minute - 195	195

Table 8.3.2-1 125V DC Class 1E Load Current Requirement (Sheet 4 of 4) Train D

Load Description	Normal Current (A)	Maximum Load Current		
		0 to 1 min (A)	1 to 119 min (A)	119 to 120 min (A)
D Switchboard Control Circuit	2	2	2	2
D Class 1E 6.9kV Switchgear	4	100	4	30
D Class 1E 480V Load Center	4	24	4	4
D Class 1E GTG Control Board	1	5	5	5
D UPS Unit	0	263	263	263
C&D MOV Inverter	1	1440	1	1
D Reactor Building DC Distribution Panel	11	15	11	11
D Solenoid Valve Distribution Panel	20	20	20	20
D Battery Charger Control Circuit	2	0	0	0
D Emergency Lighting	10	10	10	10
B MCR Radiation Monitor Pump	30	30	30	30
B Emergency Feedwater Pump Emergency Oil Pump	35	56	0	0
Total	120	1965	350	376
Random Load			For One Minute - 195	195

Notes:

1. Each Class 1E 6.9kV switchgear and 480V Load Center includes multifunction relays, auxiliary relays and indication lights for each incoming breakers and feeder breakers, and undervoltage relays.
2. Load requirement for auxiliary parts
   Multifunction relay: 0.15A
   Auxiliary relay: 0.1A
   Indication light: 0.1A
   Undervoltage relay: 0.05A

Table 8.3.2-2 125V DC Non-Class 1E Load Current Requirement (Sheet 1 of 4) N1 System

Load Description	Normal Current (A)	Maximum load Current			
		0 to 1 min (A)	1 to 5 min (A)	5 to 30 min (A)	30 to 60 min (A)
N1 Switchboard Control Circuit	2	2	2	2	2
Non-Class 1E UPS Unit N12	0	525	525	525	0
Non-Class 1E UPS Unit N32	0	525	525	525	0
Non-Class 1E UPS Unit N42	0	525	525	0	0
A/B Distribution Panel N1	30	30	30	30	30
A/B Distribution Panel N2	40	40	40	40	40
Solenoid Valve Distribution Panel	6	6	6	6	6
MCR Radiation Monitor Pump	30	30	30	30	30
Total	108	1683	1683	1158	108

Table 8.3.2-2 125V DC Non-Class 1E Load Current Requirement (Sheet 2 of 4) N2 System

Load Description	Normal Current (A)	Maximum load Current			
		0 to 1 min (A)	1 to 5 min (A)	5 to 30 min (A)	30 to 60 min (A)
N2 Switchboard Control Circuit	2	2	2	2	2
Non-Class 1E UPS Unit N11	0	525	525	525	0
Non-Class 1E UPS Unit N31	0	525	525	525	0
Non-Class 1E UPS Unit N41	0	525	525	0	0
Non-Class 1E UPS Unit N5	0	525	525	0	0
A/B Distribution Panel N3	30	30	30	30	30
A/B Distribution Panel N4	30	30	30	30	30
Main Control Room Distribution Panel	30	30	30	30	30
Solenoid Valve Distribution Panel	9	9	9	9	9
Total	101	2201	2201	1151	101

Table 8.3.2-2 125V DC Non-Class 1E Load Current Requirement (Sheet 3 of 4) N3 System

Load Description	Normal Current (A)	Maximum load Current				
		0 to 1 min (A)	1 to 30 min (A)	30 to 31 min (A)	31 to 59 min (A)	59 to 60 min (A)
N3 Switchboard Control Circuit	2	2	2	2	2	2
Vacuum Breaker	3	3	3	183	3	3
Main Generator Seal pump	350	450	350	350	350	350
T/B Distribution Panel A	1	1	1	1	1	1
Transformer Auxiliary System Distribution panel	120	120	120	120	120	120
Non-Class 1E 6.9kV P1 Switchgear	4	44	4	4	4	27
Non-Class 1E 480V P11 Load Center	5	27	5	5	5	5
Non-Class 1E 480V P12 Load Center	5	27	5	5	5	5
Non-Class 1E 13.8kV N1 Switchgear	4	60	4	4	4	27
Non-Class 1E 6.9kV N3 Switchgear	4	44	4	4	4	27
Non-Class 1E 6.9kV N4 Switchgear	4	44	4	4	4	27
Non-Class 1E 480V N1 Load Center	5	27	5	5	5	5
Non-Class 1E 480V N3 Load Center	5	27	5	5	5	5
Non-Class 1E 480V N4 Load Center	5	27	5	5	5	5
Non-Class 1E UPS Unit N22	0	525	525	0	0	0
Secondary System Solenoid Valve Distribution Panel	22	22	22	22	22	22
Total	539	1450	1064	719	539	631

Table 8.3.2-2 125V DC Non-Class 1E Load Current Requirement (Sheet 4 of 4)
N4 System

Load Description	Normal Current (A)	Maximum load Current				
		0 to 1 min (A)	1 to 30 min (A)	30 to 31 min (A)	31 to 59 min (A)	59 to 60 min (A)
N4 Switchboard Control Circuit	2	2	2	2	2	2
Turbine Oil Pump	1000	1500	1000	1000	1000	1000
T/B Distribution Panel B	2	2	2	2	2	2
Transformer Auxiliary System Distribution panel	80	80	80	80	80	80
Non-Class 1E 6.9kV P2 Switchgear	4	44	4	4	4	27
Non-Class 1E 480V P21 Load Center	5	27	5	5	5	5
Non-Class 1E 480V P22 Load Center	5	27	5	5	5	5
Non-Class 1E 13.8kV N2 Switchgear	4	60	4	4	4	27
Non-Class 1E 6.9kV N5 Switchgear	4	44	4	4	4	27
Non-Class 1E 6.9kV N6 Switchgear	4	44	4	4	4	27
Non-Class 1E 480V N2 Load Center	5	27	5	5	5	5
Non-Class 1E 480V N5 Load Center	5	27	5	5	5	5
Non-Class 1E 480V N6 Load Center	5	27	5	5	5	5
Non-Class 1E UPS Unit N21	0	525	525	0	0	0
Secondary System Solenoid Valve Distribution Panel	24	24	24	24	24	24
Total	1149	2460	1674	1149	1149	1241

Notes:

1. Each Non-Class 1E 6.9kV switchgear and 480V Load Center includes multifunction relays, auxiliary relays and indication lights for each incoming breakers and feeder breakers, and undervoltage relays.
2. Load requirement for auxiliary parts
   Multifunction relay: 0.15A
   Auxiliary relay: 0.1A
   Indication light: 0.1A
   Undervoltage relay: 0.05A
3. The DC loads are preliminary and typical, and are subject to change during detailed design.

Table 8.3.2-3 Electrical Equipment Ratings - Component Data (Sheet 1 of 2)
Class 1E DC Power System
(Nominal Values)

a. Battery Bank 4 - 125Vdc, 2 strings of 60 flooded lead acid cells, 5000Ah*, float voltage 2.25V/cell, equalize voltage 2.33V/cell, 8 hr rating
b. Battery Charger 4 - ac input – 480V, 3 phase, 60Hz; dc output – 125Vdc, 700A Continuous; float voltage – 135V, equalizing charge voltage 140V, 24hr recharge
c. Switchboard 4 – 125Vdc, Main bus 3000A, 50kA short circuit
d. Panelboards 4 - Main bus 225A continuous, 40kA short circuit
e. **Spare Battery Charger** (Non-class 1E) 2 - ac input – 480V, 3 phase, 60Hz; dc output – 125Vdc, 700A Continuous; float voltage – 135V, equalizing charge voltage 140V, 24hr recharge

*: Actual Ah rating is decided in accordance with manufacturer's specification.

Table 8.3.2-3 Electrical Equipment Ratings - Component Data
(Sheet 2 of 2)
Non-Class 1E DC Power System
(Nominal Values)

a. Battery Bank 1 - 125Vdc 60 flooded lead acid cells, 3600Ah*, float voltage 2.25V/cell, equalize voltage 2.33V/cell, 8 hr rating 1 - 125Vdc 60 flooded lead acid cells, 4560Ah*, float voltage 2.25V/cell, equalize voltage 2.33V/cell, 8 hr rating 1 - 125Vdc 60 flooded lead acid cells, 3650Ah*, float voltage 2.25V/cell, equalize voltage 2.33V/cell, 8 hr rating 1 - 125Vdc 60 flooded lead acid cells, 5140Ah*, float voltage 2.25V/cell, equalize voltage 2.33V/cell, 8 hr rating
b. Battery Charger 2 - ac input – 480V, 3 phase, 60Hz; dc output – 125Vdc, 200A Continuous; float voltage – 135V, equalizing charge voltage 140V, 24hr recharge 1 - ac input – 480V, 3 phase, 60Hz; dc output – 125Vdc, 700A Continuous; float voltage – 135V, equalizing charge voltage 140V, 24hr recharge 1 - ac input – 480V, 3 phase, 60Hz; dc output – 125Vdc, 1300A Continuous; float voltage – 135V, equalizing charge voltage 140V, 24hr recharge
c. Switchboard 1 – 125Vdc, Main Bus 2000A, 40kA short circuit 1 – 125Vdc, Main Bus 3000A, 40kA short circuit 1 – 125Vdc, Main Bus 2000A, 40kA short circuit 1 – 125Vdc, Main Bus 3000A, 50kA short circuit
d. Spare Battery Charger 1 - ac input – 480V, 3 phase, 60Hz; dc output – 125Vdc, 200A Continuous; float voltage – 135V, equalizing charge voltage 140V, 24hr recharge 1 - ac input – 480V, 3 phase, 60Hz; dc output – 125Vdc, 1300A Continuous; float voltage – 135V, equalizing charge voltage 140V, 24hr recharge

*: Actual Ah rating is decided in accordance with manufacturer’s specification.

Table 8.3.2-4 Class 1E 125V DC Power System Failure Modes and Effects Analysis

Components	Function	Failure Mode(s)	Method of Failure Detection	Effect on System Safety Function	Remarks
Spare battery charger AB Spare battery charger CD	Supply dc power to dc switch board with maintaining battery charged	• No output • Failure such as short circuit	Annunciator in main control room.	None; Safety-related function is maintained by redundant trains.	When spare battery charger is used, function of associated class 1E battery charger is inoperable

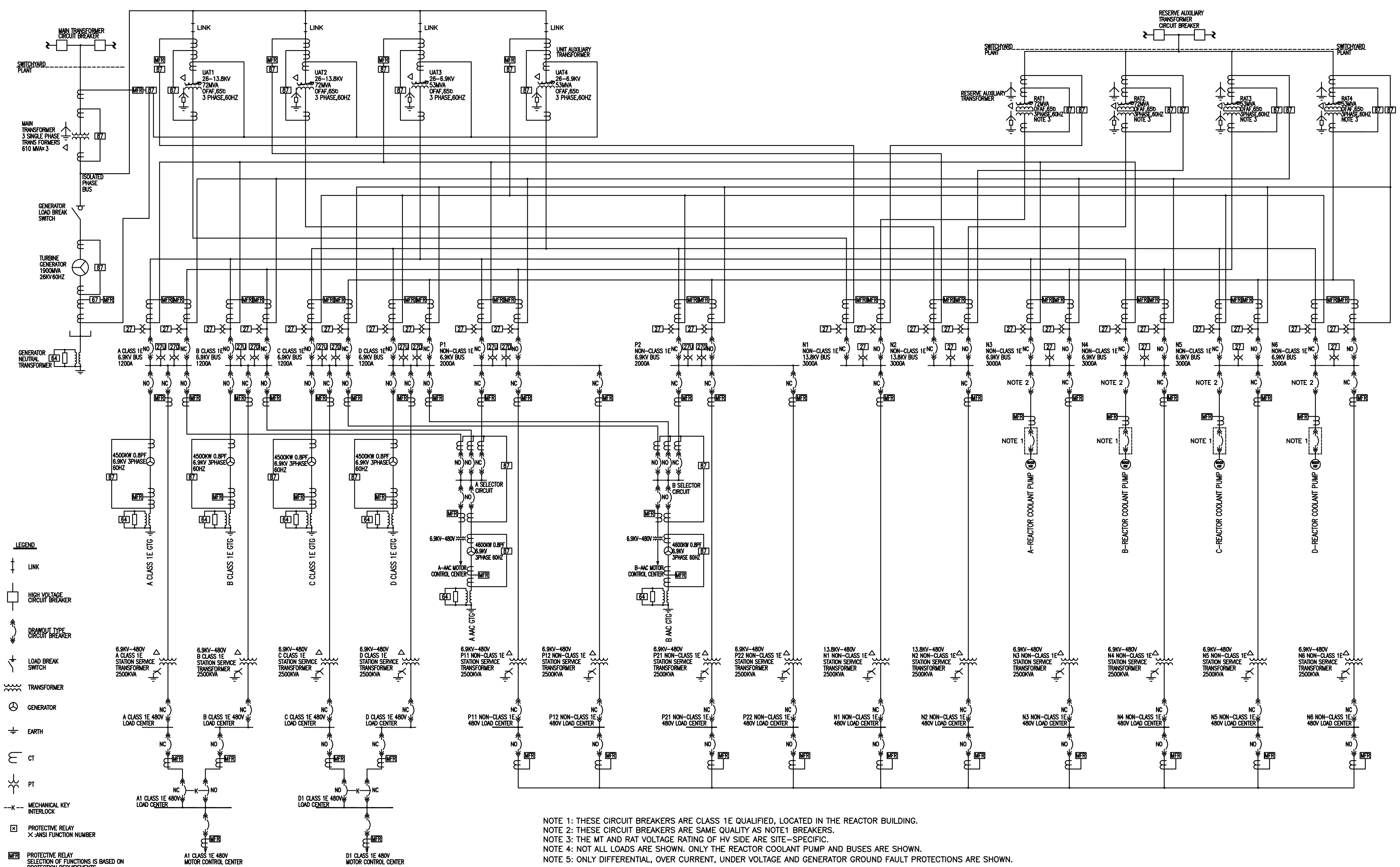


Figure 8.3.1-1 Onsite AC electrical distribution system (Sheet 1 of 8) Main one line diagram

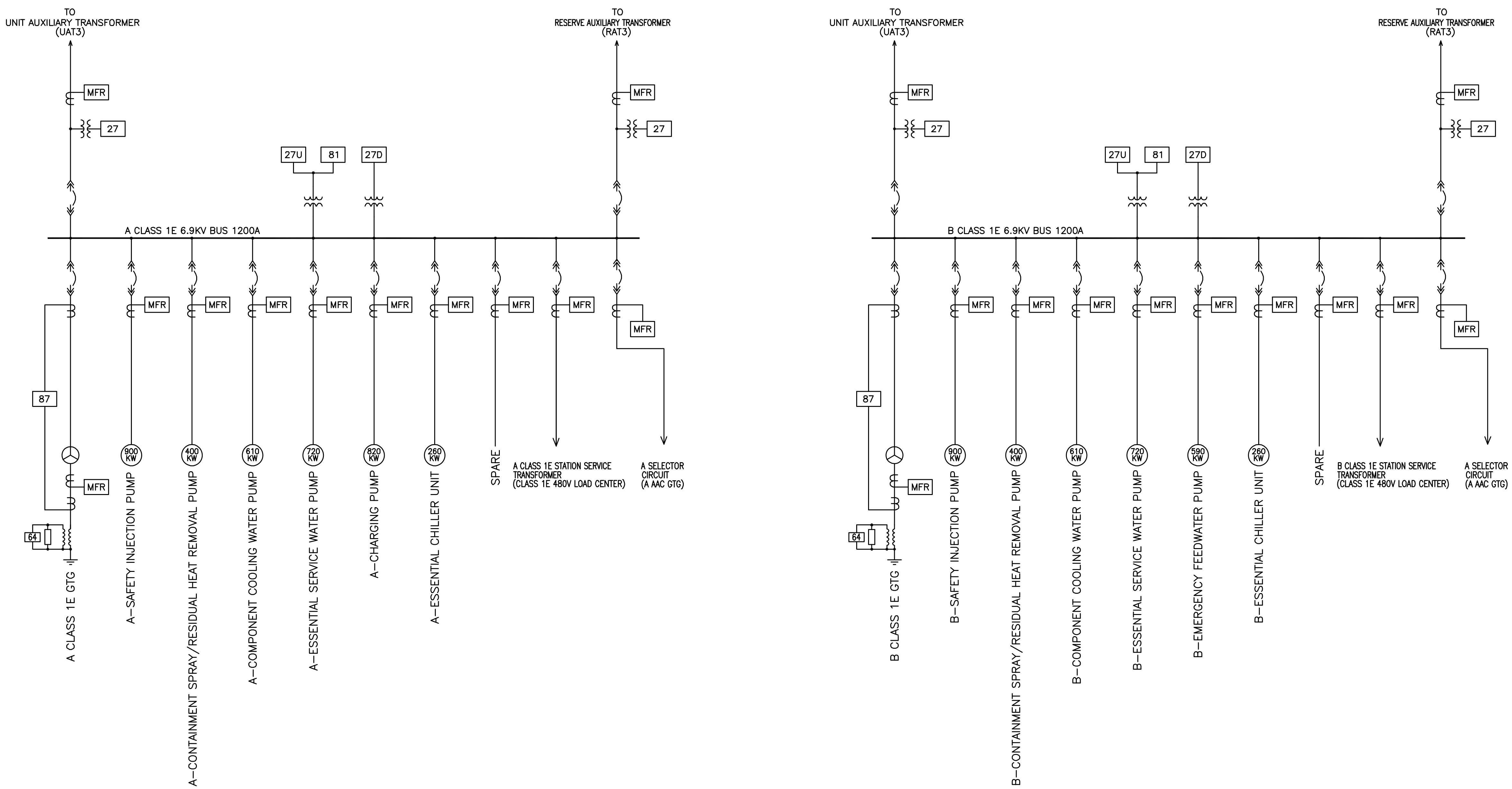


Figure 8.3.1-1 Onsite AC electrical distribution system (Sheet 2 of 8)
Class 1E 6.9kV buses A and B one line diagram

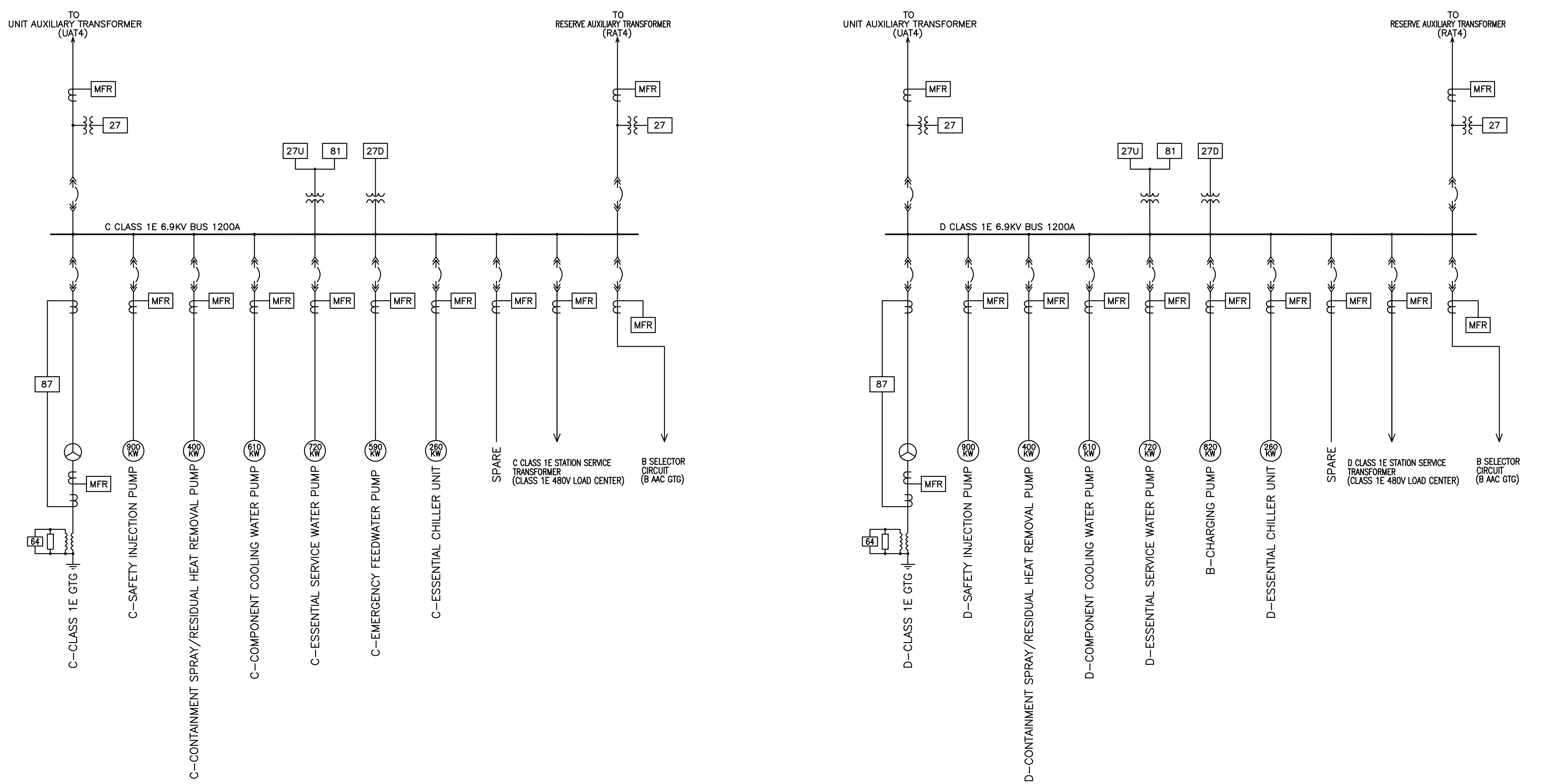


Figure 8.3.1-1 Onsite AC electrical distribution system (Sheet 3 of 8)
Class 1E 6.9kV buses C and D one line diagram

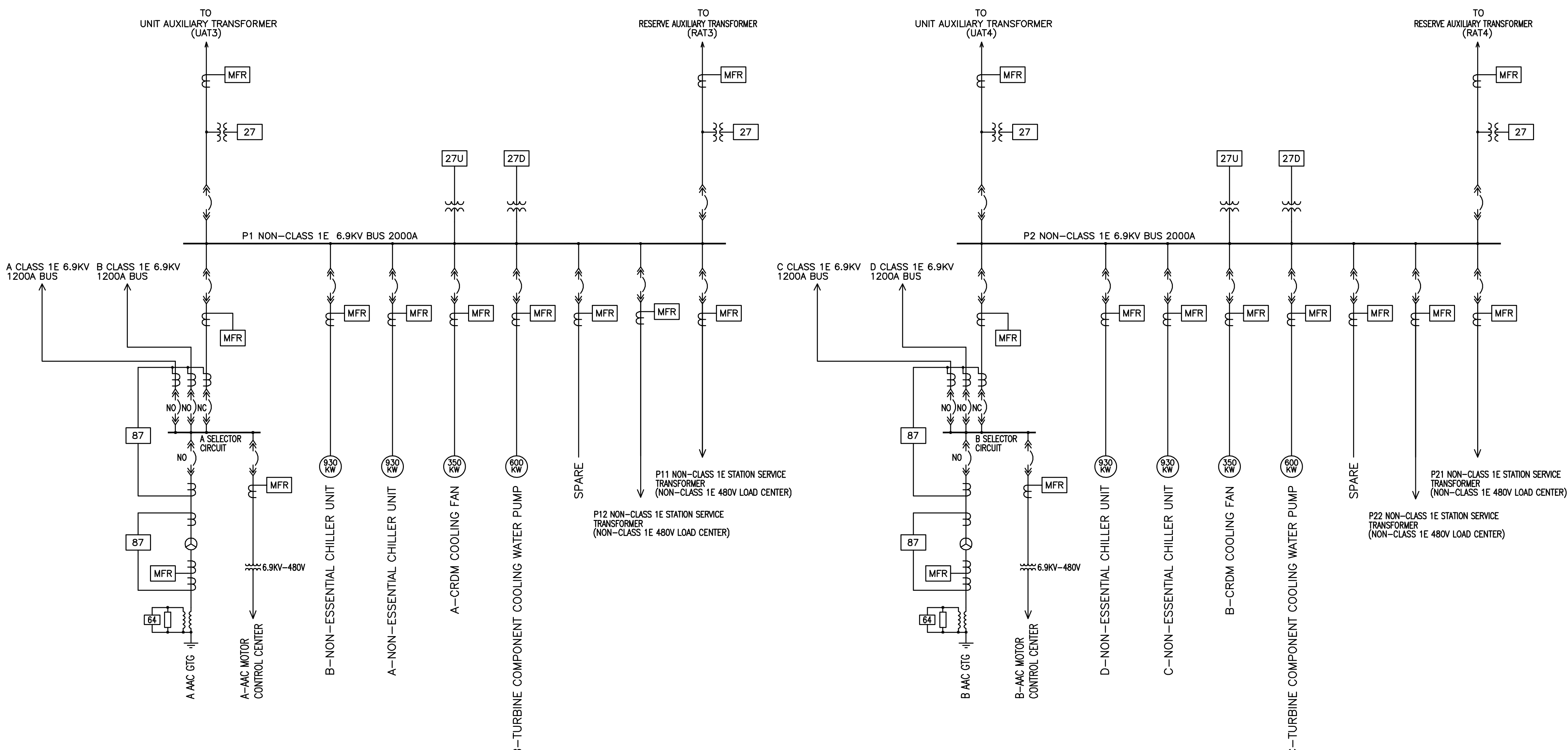


Figure 8.3.1-1 Onsite AC electrical distribution system (Sheet 4 of 8)
Non-Class 1E 6.9kV permanent buses P1 and P2 one line diagram

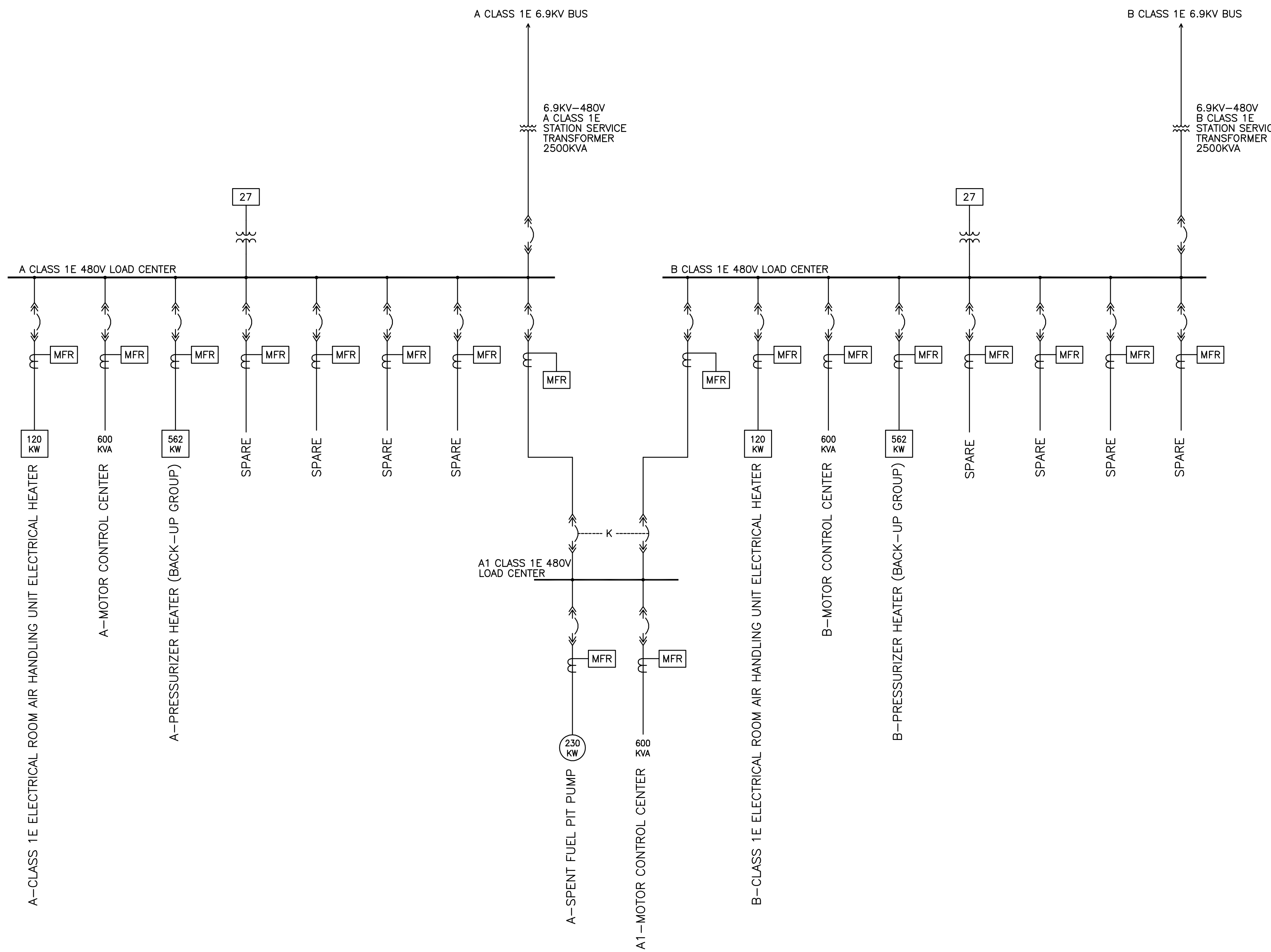


Figure 8.3.1-1 Onsite AC electrical distribution system (Sheet 5 of 8)
Class 1E 480V buses A and B one line diagram

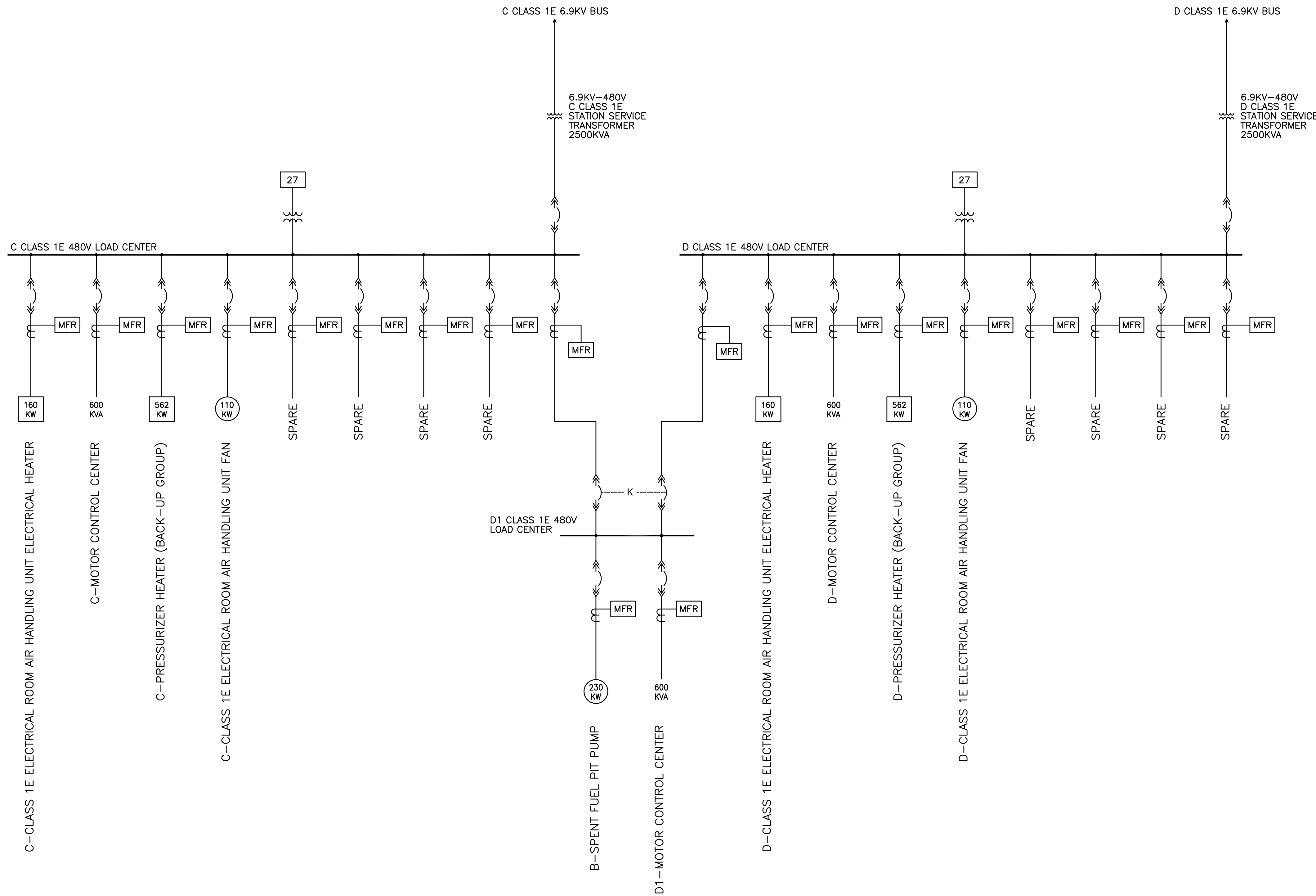


Figure 8.3.1-1 Onsite AC electrical distribution system (Sheet 6 of 8)
Class 1E 480V buses C and D one line diagram

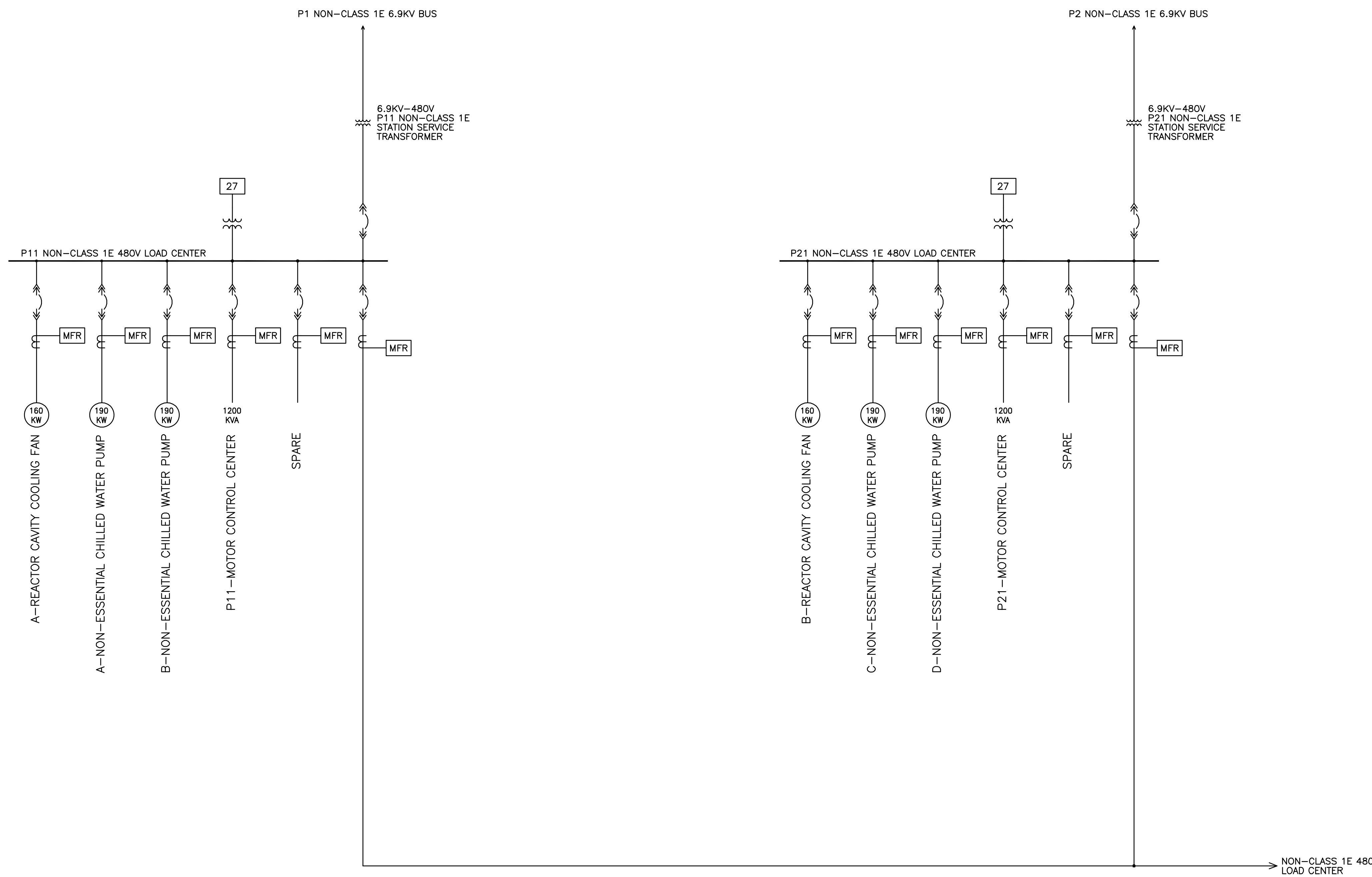


Figure 8.3.1-1 Onsite AC electrical distribution system (Sheet 7 of 8)
Non-Class 1E 480V permanent buses P11 and P21 one line diagram

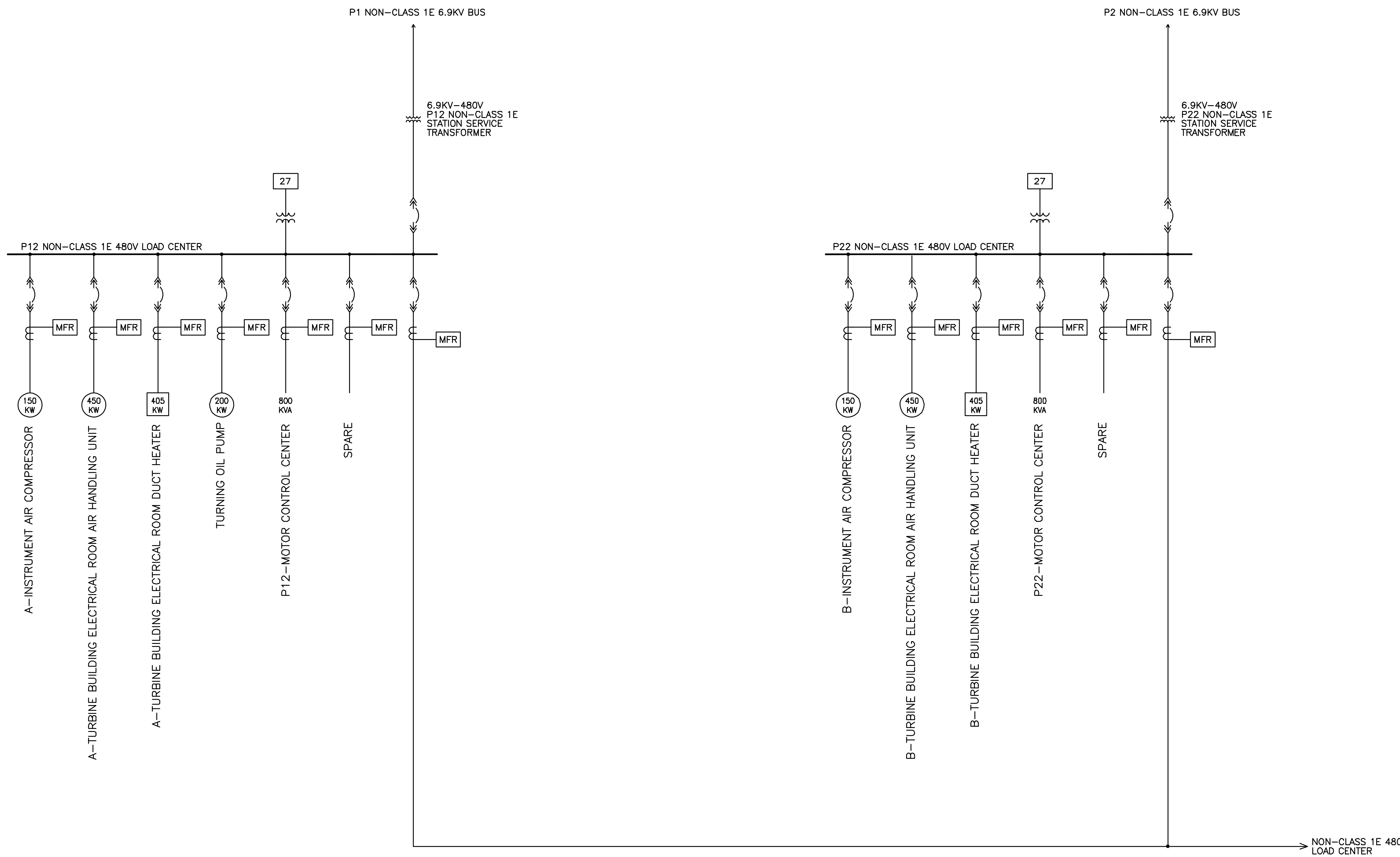


Figure 8.3.1-1 Onsite AC electrical distribution system (Sheet 8 of 8)
Non-Class 1E 480V permanent buses P12 and P22 one line diagram

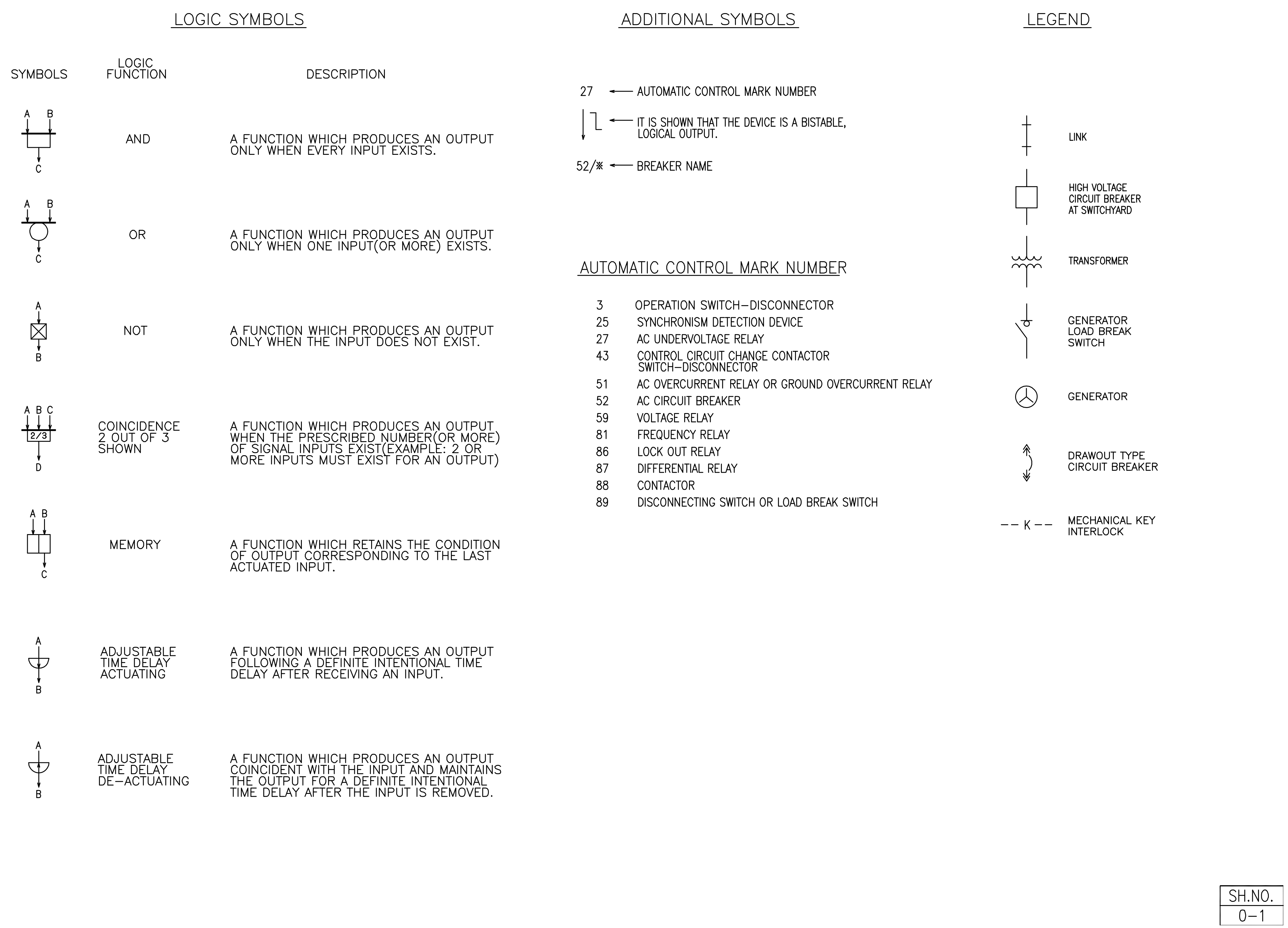


Figure 8.3.1-2 Logic diagrams (Sheet 1 of 24)
Logic diagram index and symbols

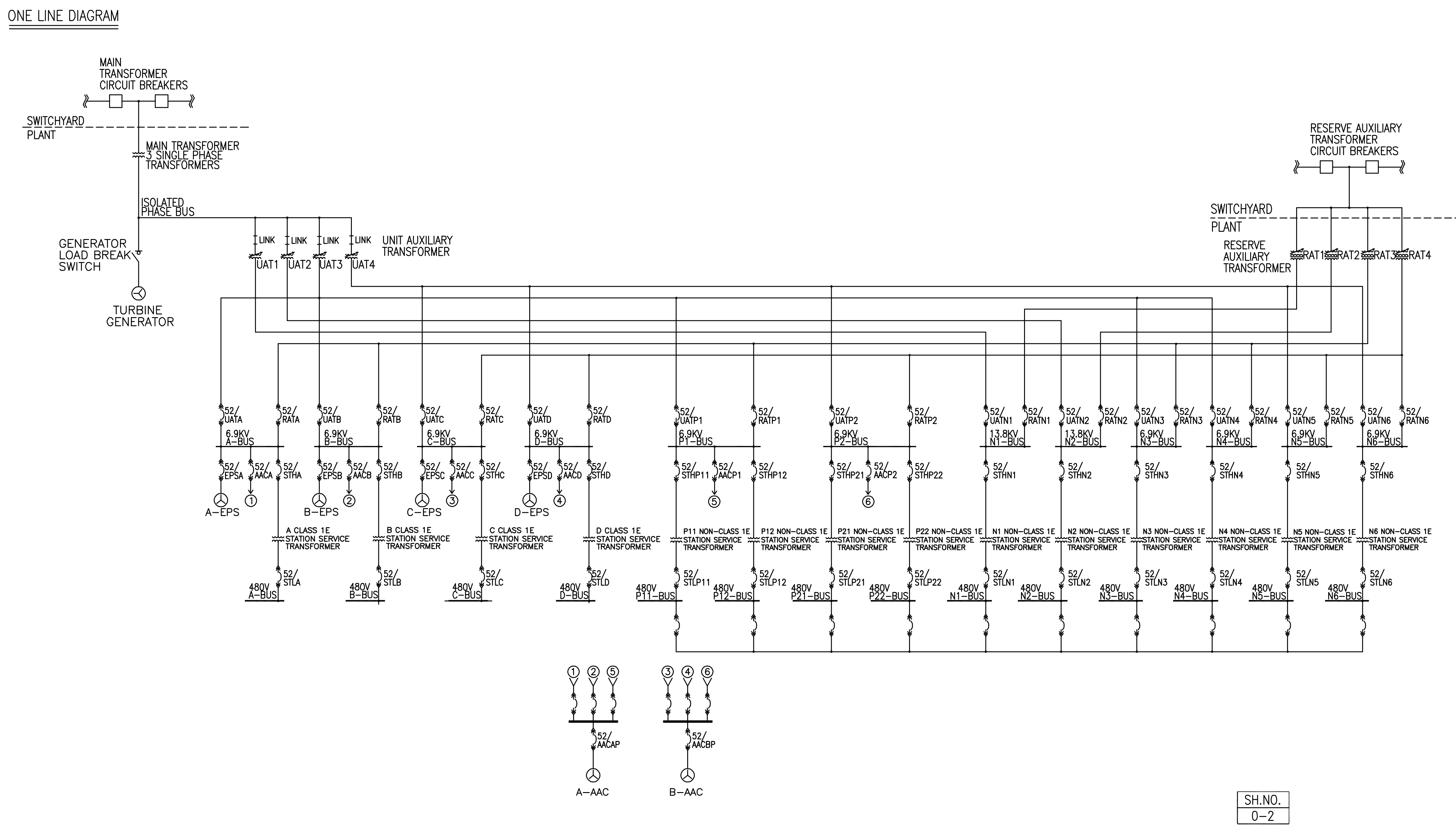


Figure 8.3.1-2 Logic diagrams (Sheet 2 of 24)
One line diagram

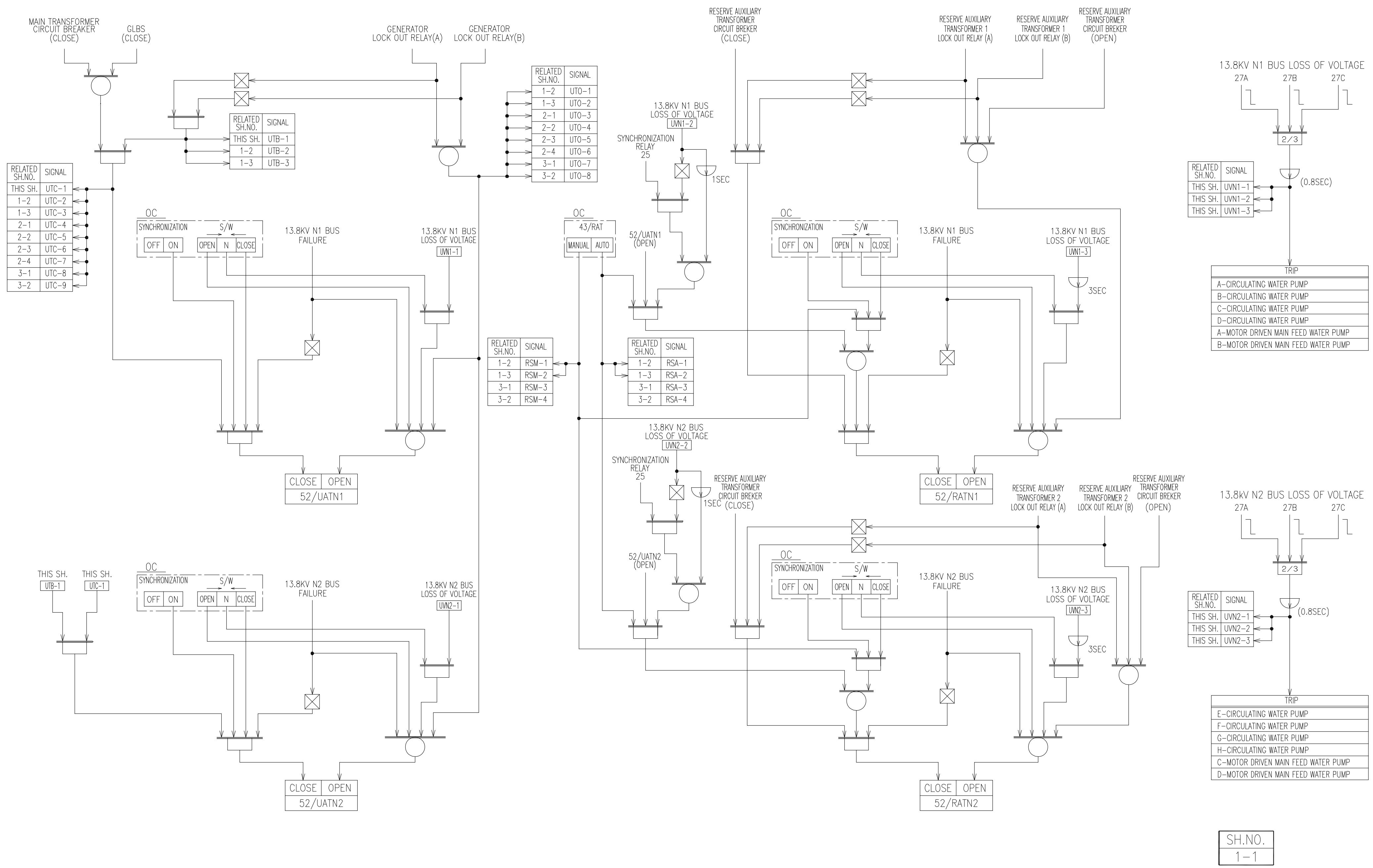


Figure 8.3.1-2 Logic diagrams (Sheet 3 of 24)
Non-Class 1E 13.8kV incoming circuit breaker tripping and closing

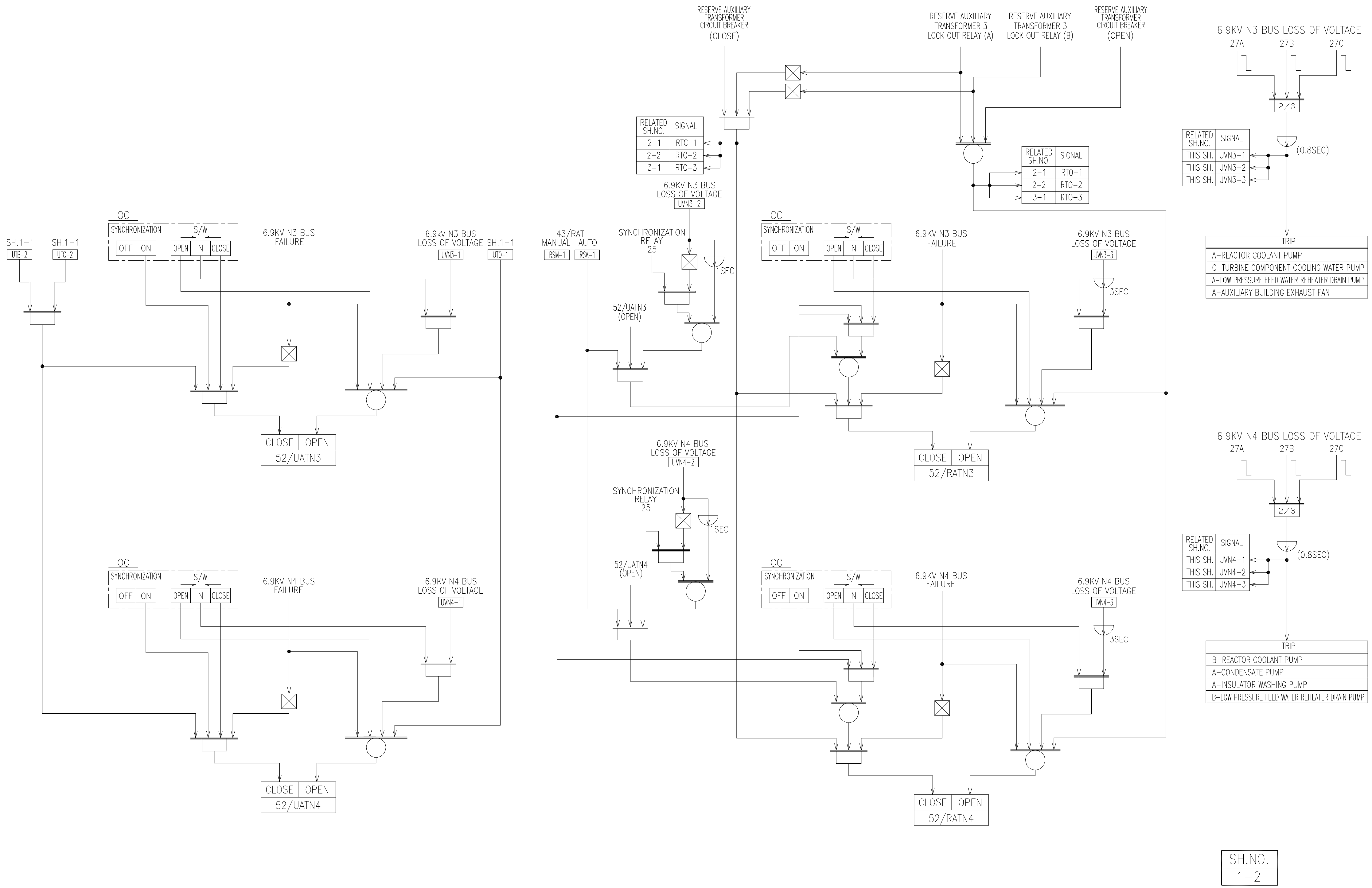


Figure 8.3.1-2 Logic diagrams (Sheet 4 of 24)
Non-Class 1E 6.9kV incoming circuit breaker (N3 & N4 buses) tripping and closing

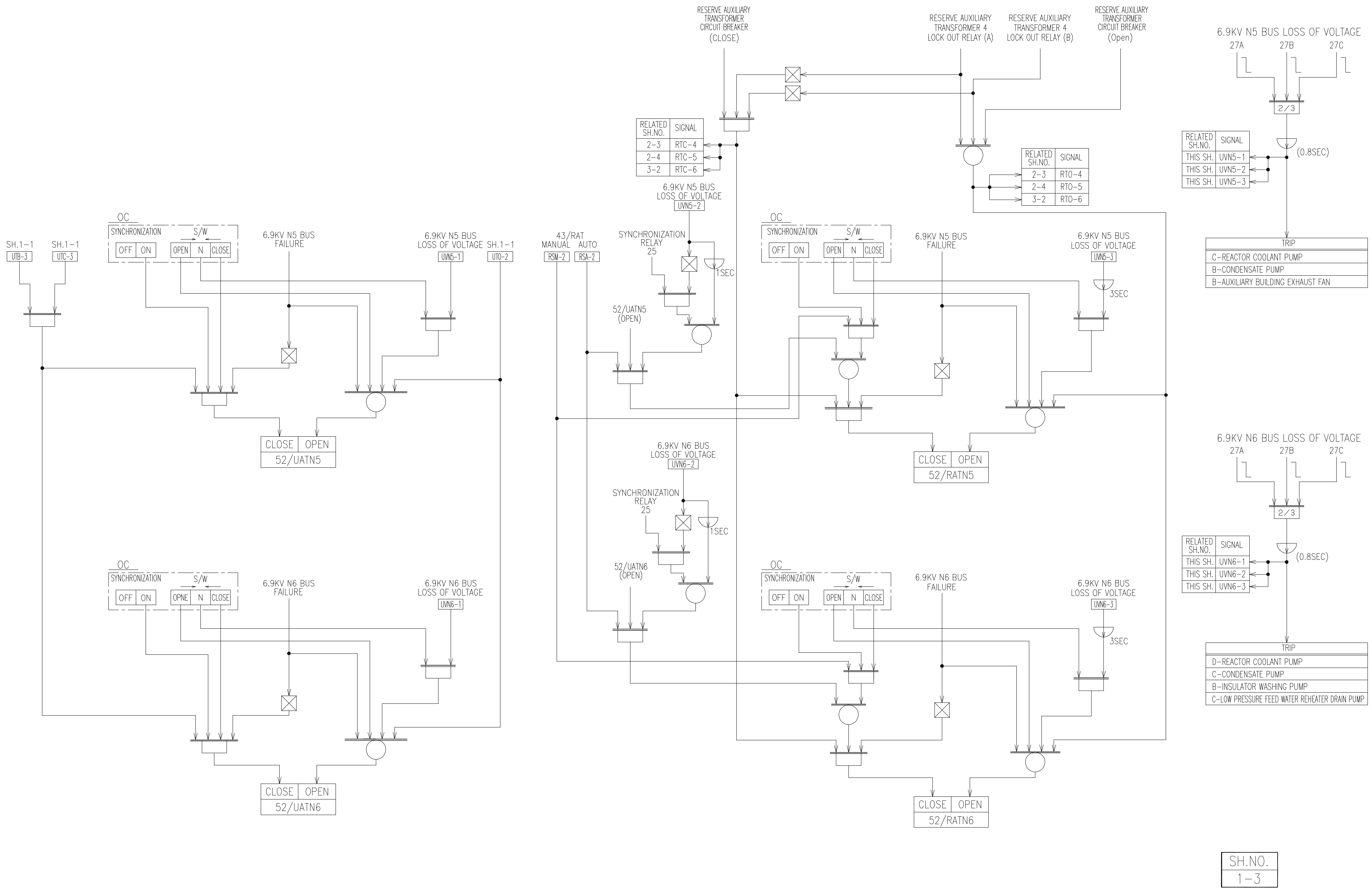


Figure 8.3.1-2 Logic diagrams (Sheet 5 of 24)
Non-Class 1E 6.9kV incoming circuit breaker (N5 & N6 buses) tripping and closing

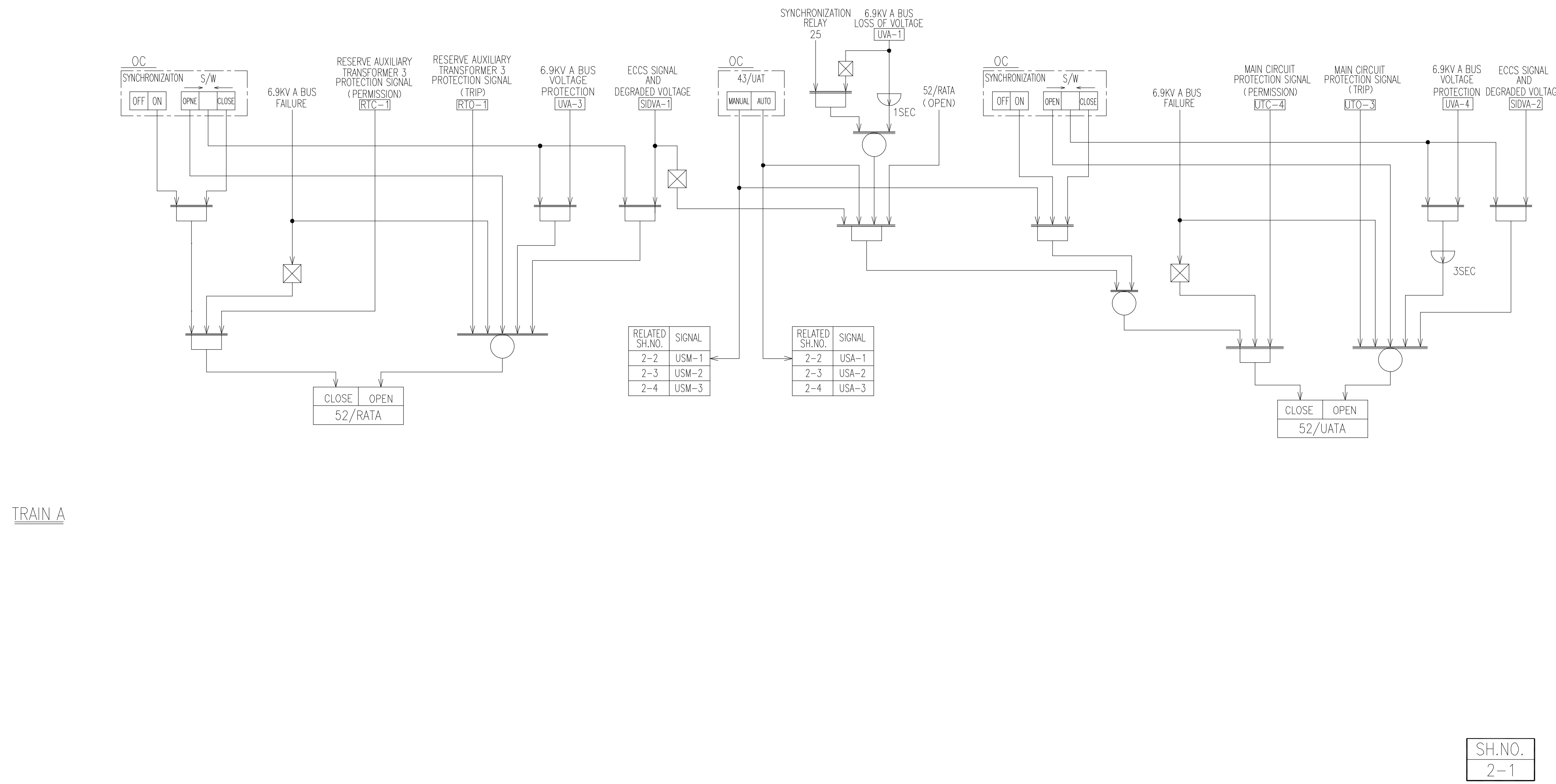


Figure 8.3.1-2 Logic diagrams (Sheet 6 of 24)
A-Class 1E 6.9kV bus incoming circuit breaker tripping and closing

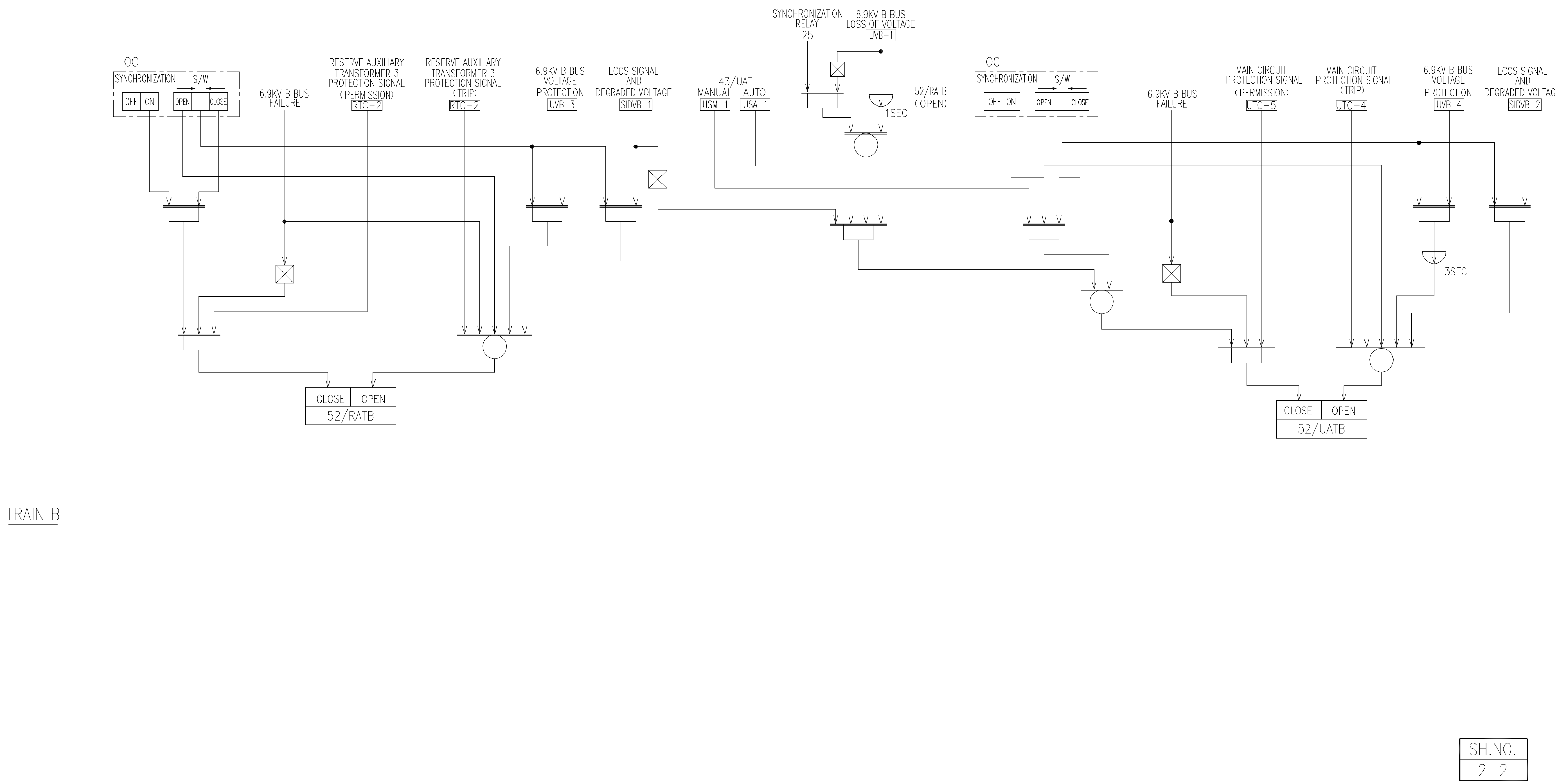


Figure 8.3.1-2 Logic diagrams (Sheet 7 of 24)
B-Class 1E 6.9kV bus incoming circuit breaker tripping and closing

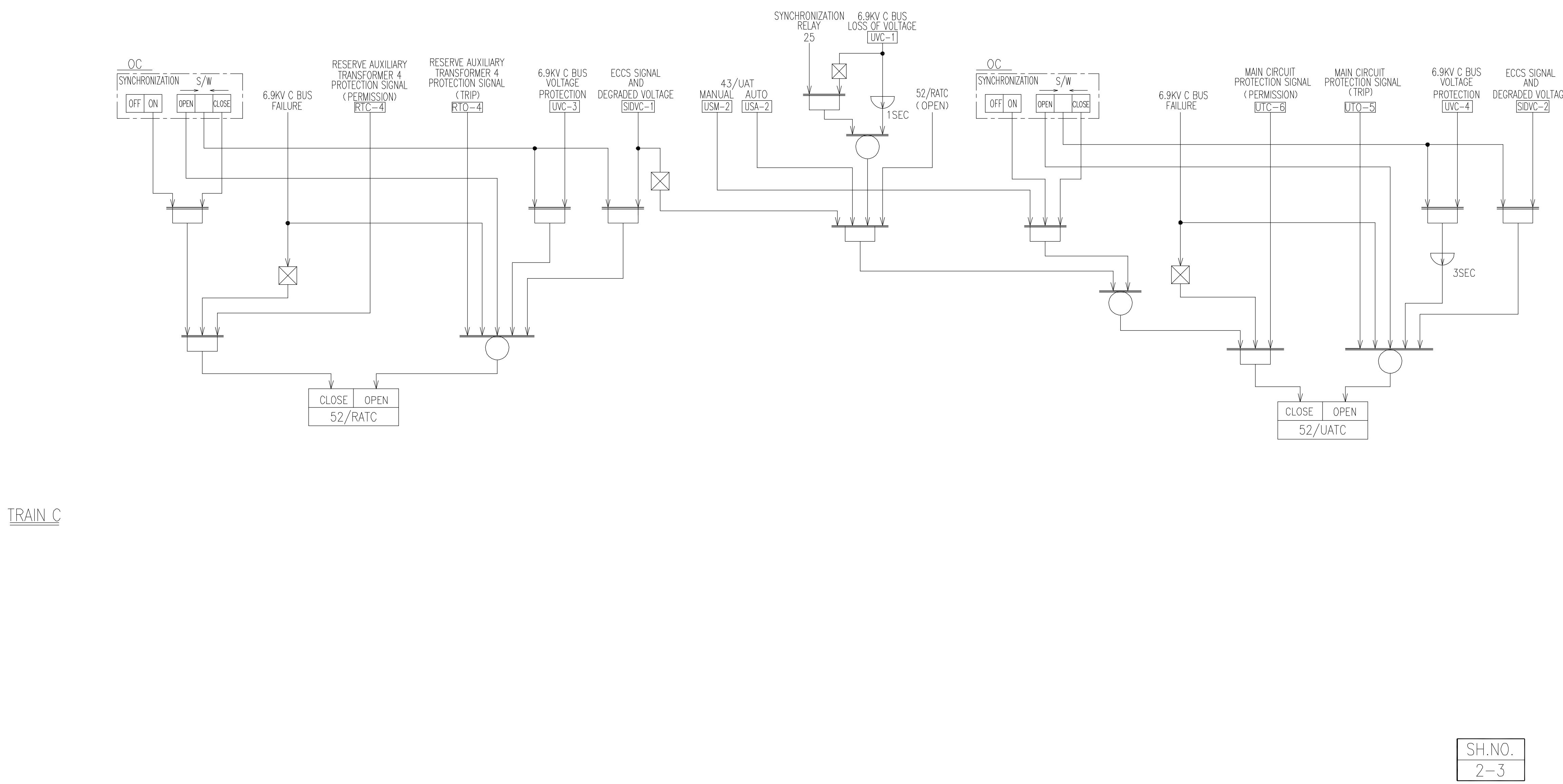


Figure 8.3.1-2 Logic diagrams (Sheet 8 of 24)
C-Class 1E 6.9kV bus incoming circuit breaker tripping and closing

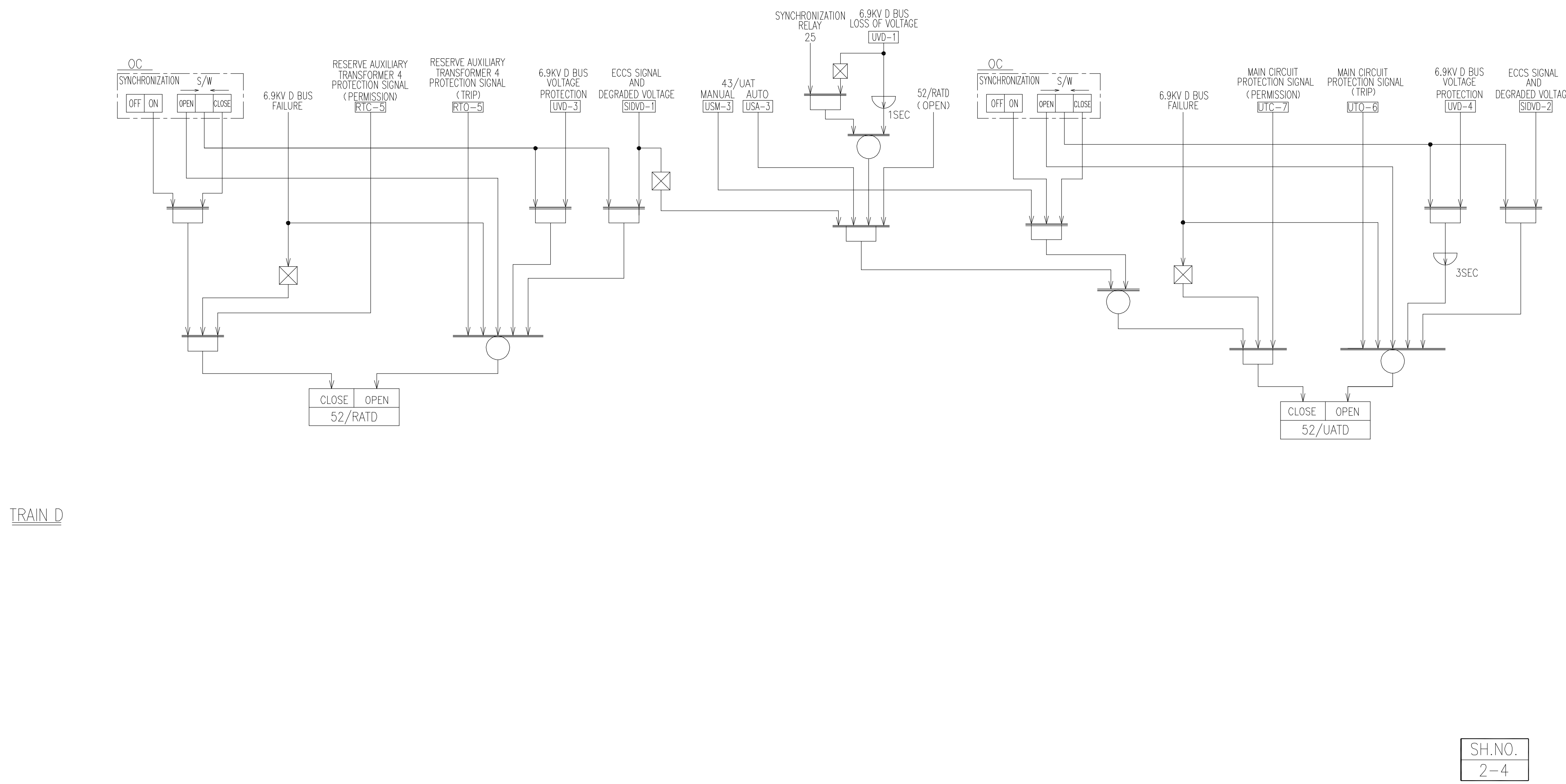


Figure 8.3.1-2 Logic diagrams (Sheet 9 of 24)
D-Class 1E 6.9kV bus incoming circuit breaker tripping and closing

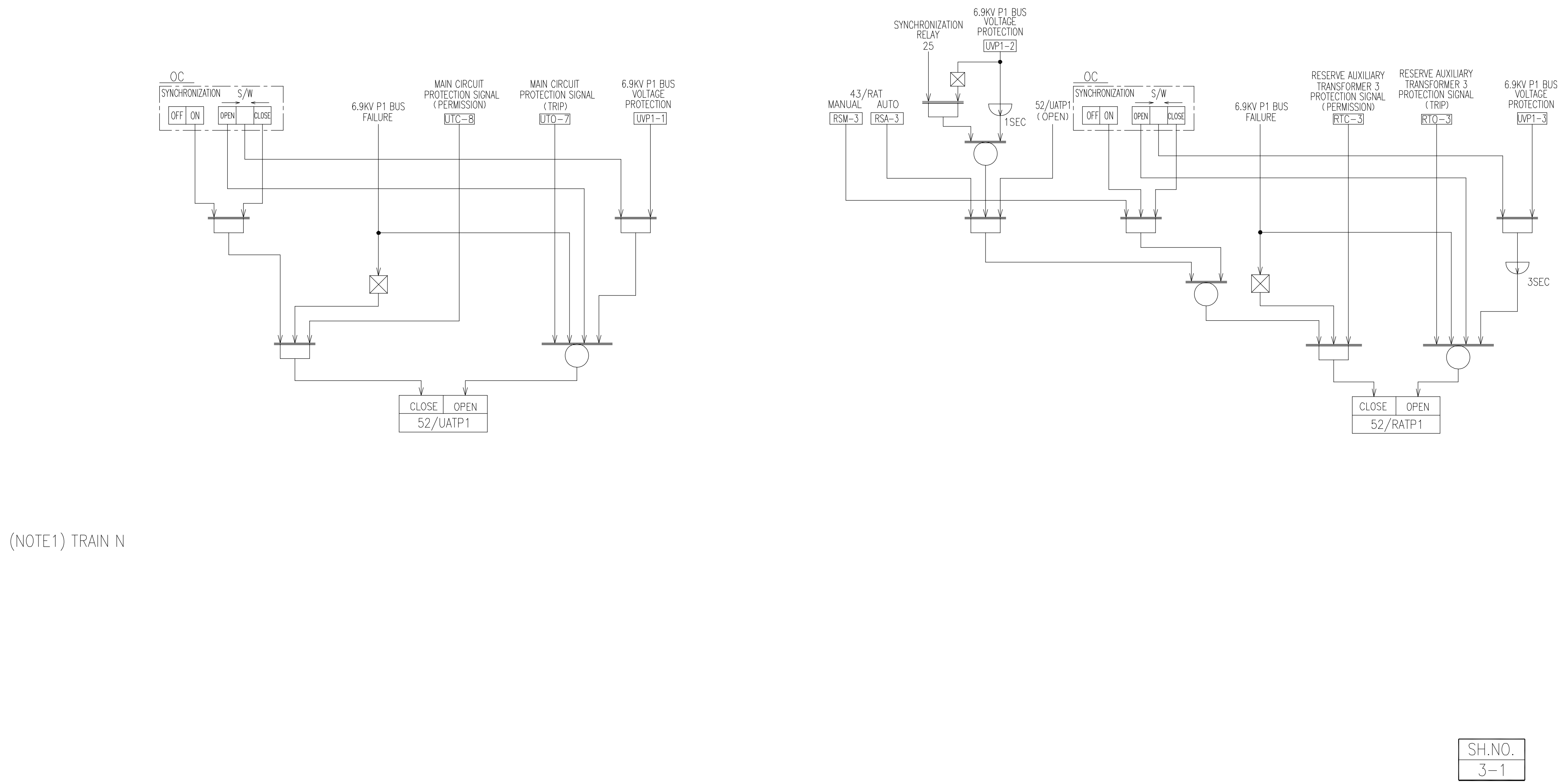


Figure 8.3.1-2 Logic diagrams (Sheet 10 of 24)
P1-Non-Class 1E 6.9kV permanent bus incoming circuit breaker tripping and closing

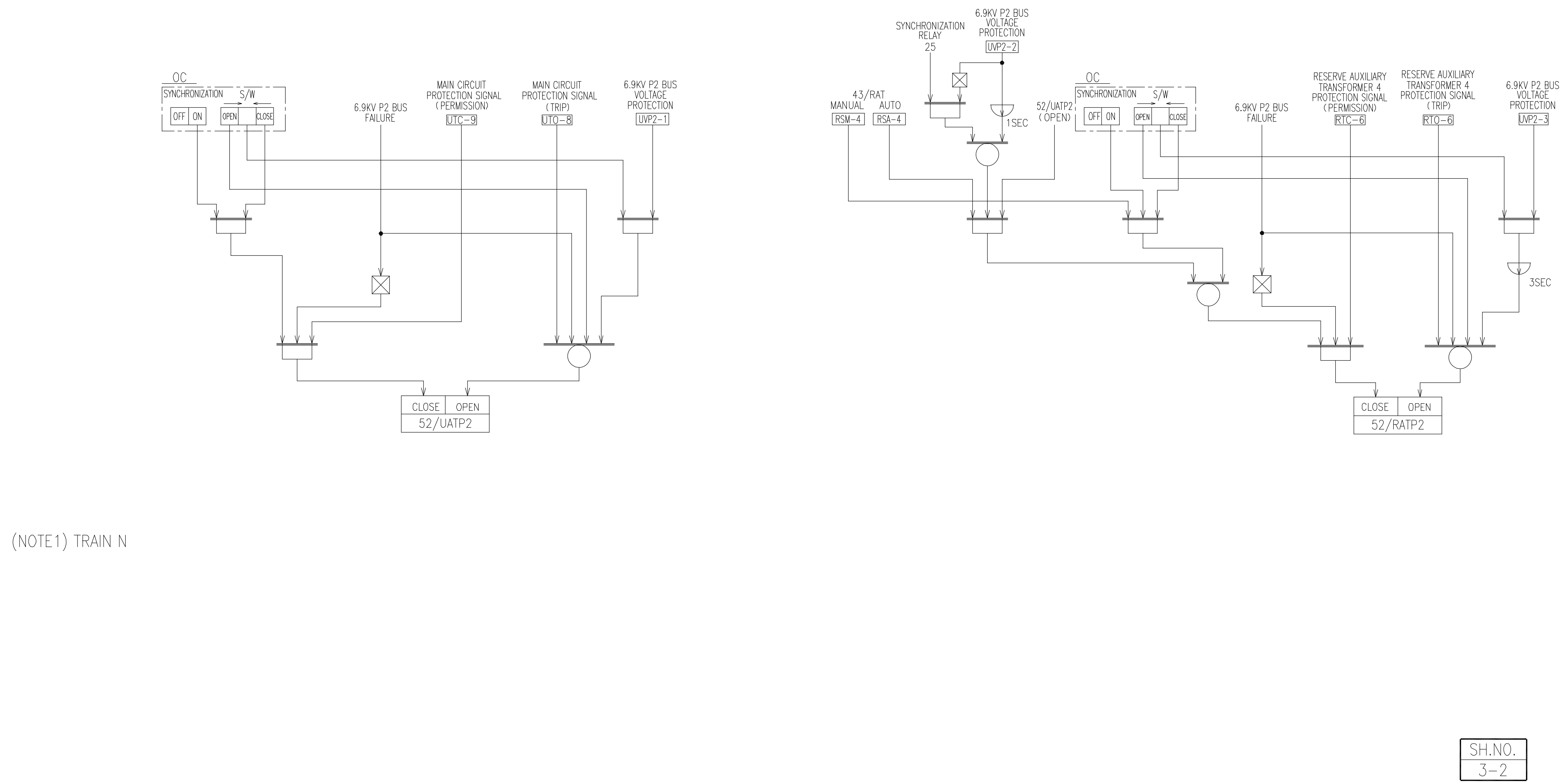
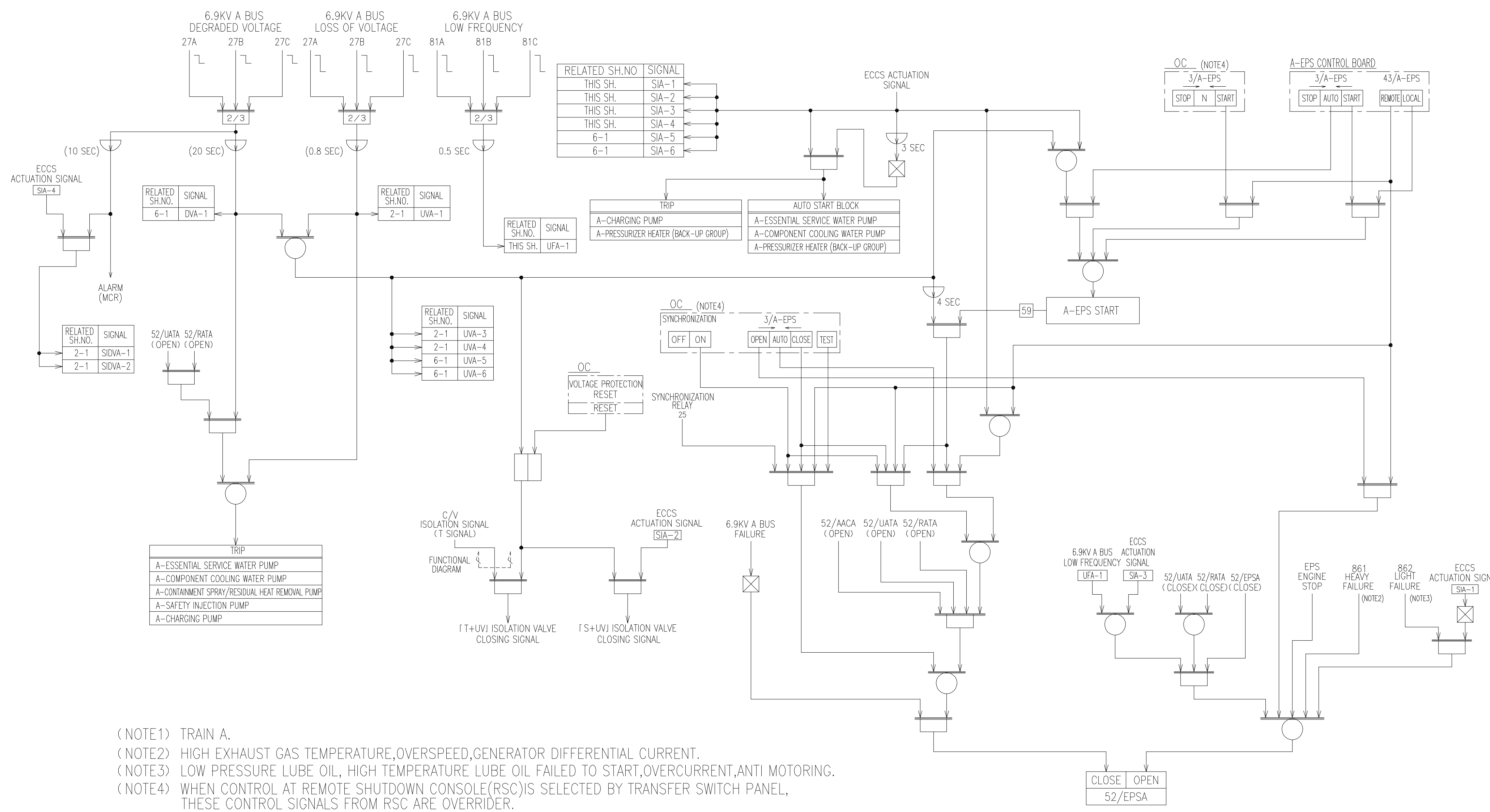


Figure 8.3.1-2 Logic diagrams (Sheet 11 of 24)
P2-Non-Class 1E 6.9kV permanent bus incoming circuit breaker tripping and closing



(NOTE1) TRAIN A.
(NOTE2) HIGH EXHAUST GAS TEMPERATURE,OVERSPEED,GENERATOR DIFFERENTIAL CURRENT.
(NOTE3) LOW PRESSURE LUBE OIL, HIGH TEMPERATURE LUBE OIL FAILED TO START,OVERCURRENT,ANTI MOTORING.
(NOTE4) WHEN CONTROL AT REMOTE SHUTDOWN CONSOLE(RSC)IS SELECTED BY TRANSFER SWITCH PANEL, THESE CONTROL SIGNALS FROM RSC ARE OVERRIDER.

SH.NO. 4-1

Figure 8.3.1-2 Logic diagrams (Sheet 12 of 24)
A-Class 1E GTG starting initiation and circuit breaker closing

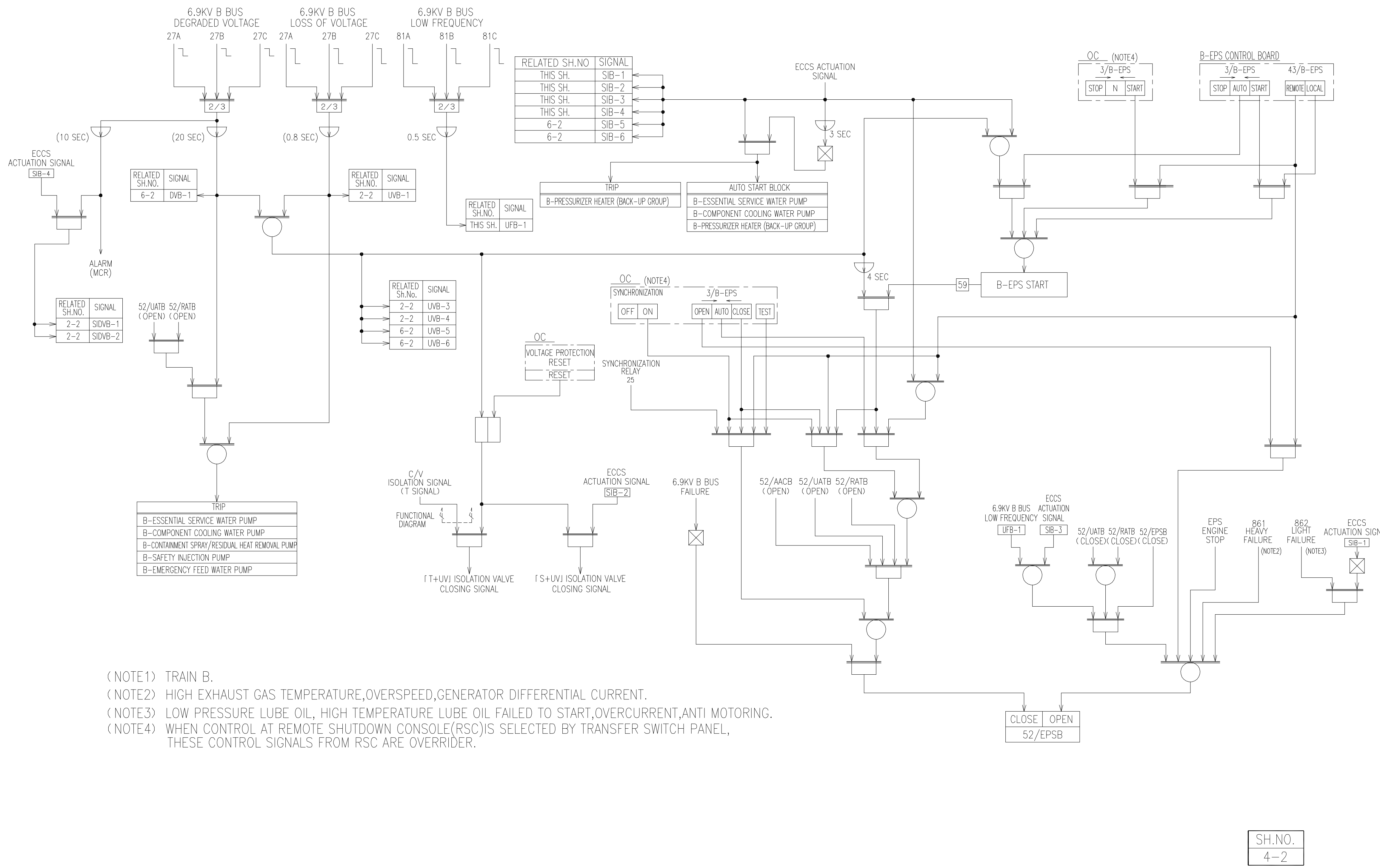
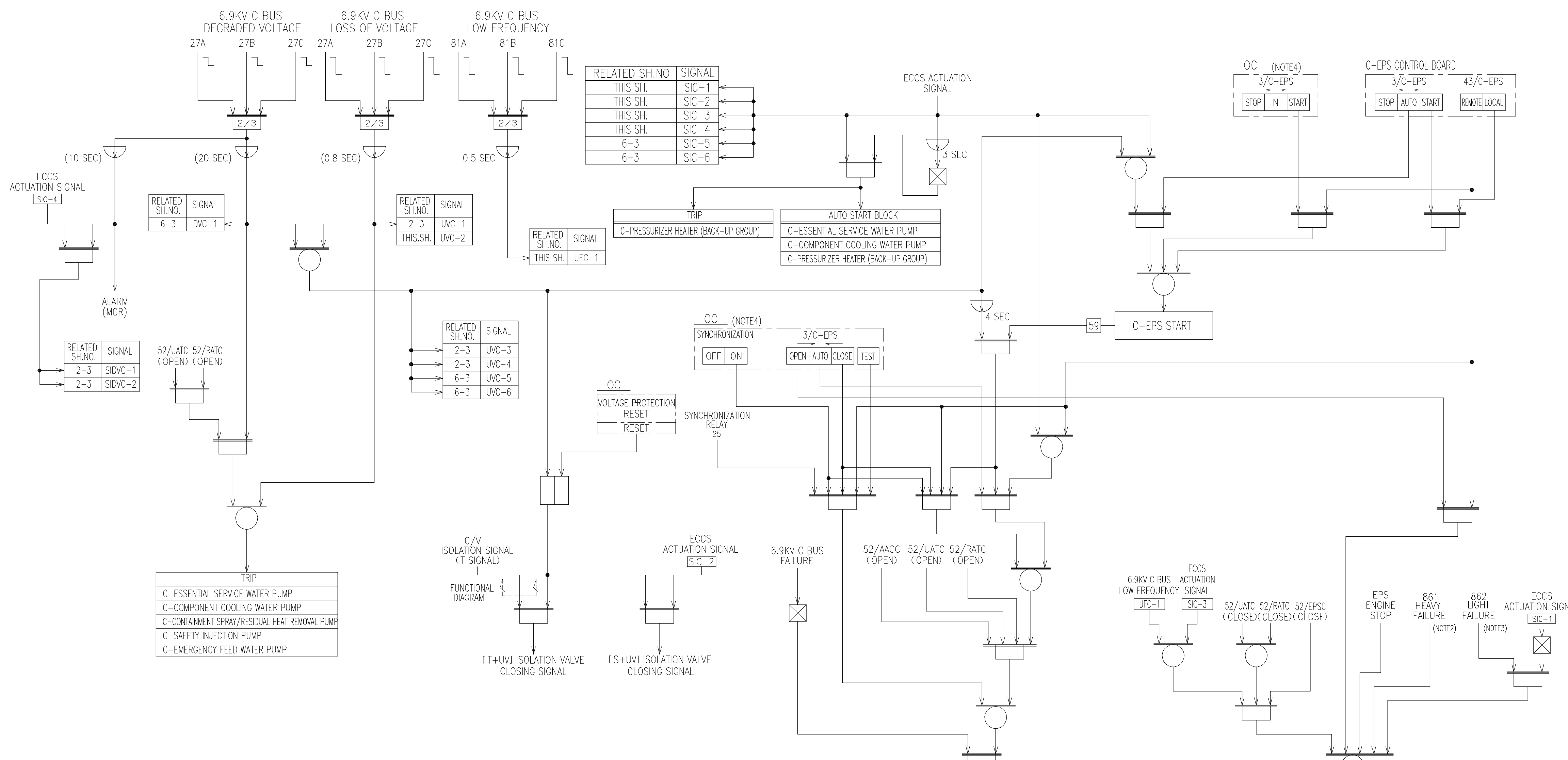


Figure 8.3.1-2 Logic diagrams (Sheet 13 of 24)
B-Class 1E GTG starting initiation and circuit breaker closing



(NOTE1) TRAIN C.
(NOTE2) HIGH EXHAUST GAS TEMPERATURE,OVERSPEED,GENERATOR DIFFERENTIAL CURRENT.
(NOTE3) LOW PRESSURE LUBE OIL, HIGH TEMPERATURE LUBE OIL FAILED TO START,OVERCURRENT,ANTI MOTORING.
(NOTE4) WHEN CONTROL AT REMOTE SHUTDOWN CONSOLE(RSC)IS SELECTED BY TRANSFER SWITCH PANEL, THESE CONTROL SIGNALS FROM RSC ARE OVERRIDER.

SH.NO.
4-3

Figure 8.3.1-2 Logic diagrams (Sheet 14 of 24)
C-Class 1E GTG starting initiation and circuit breaker closing

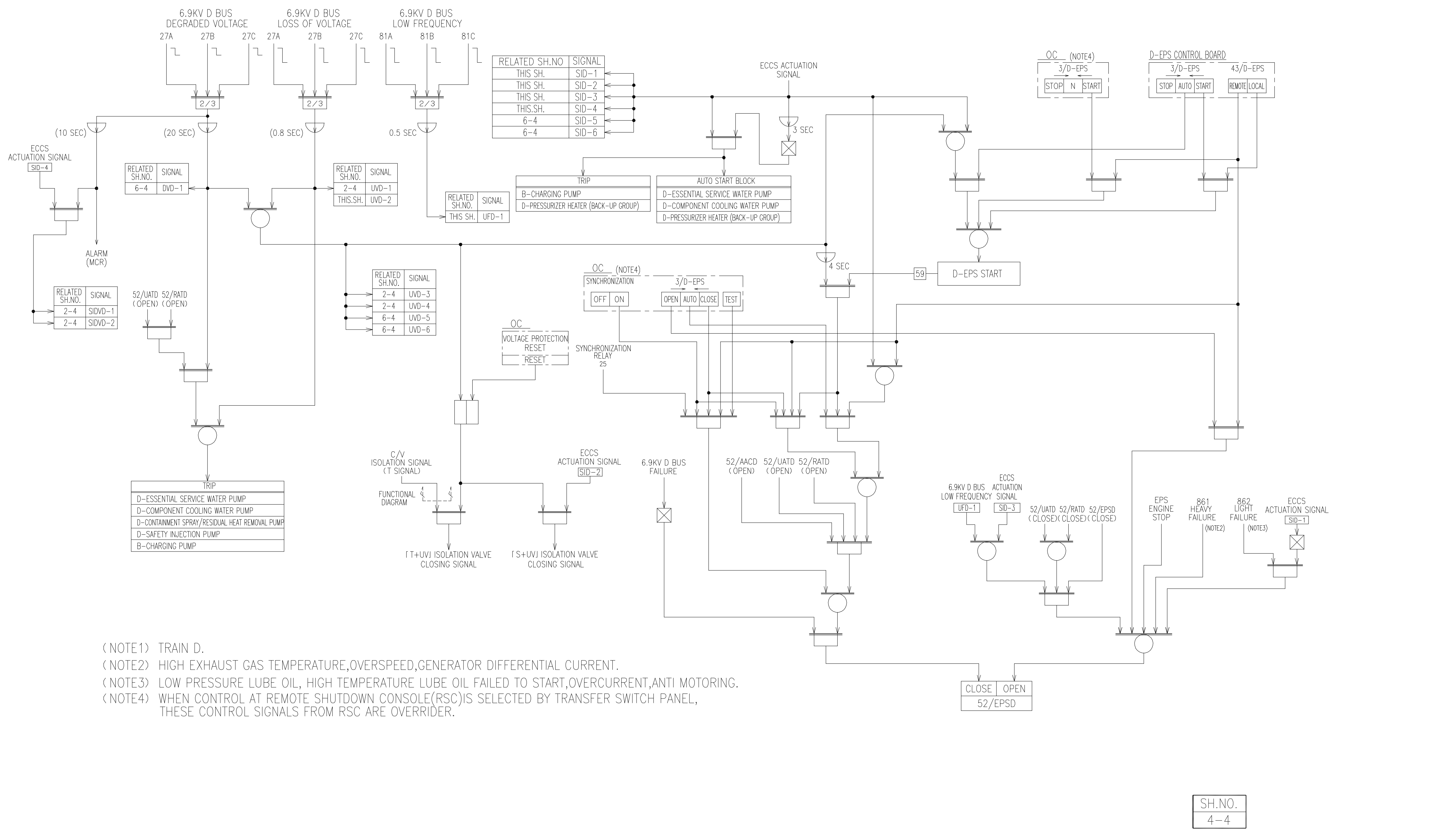
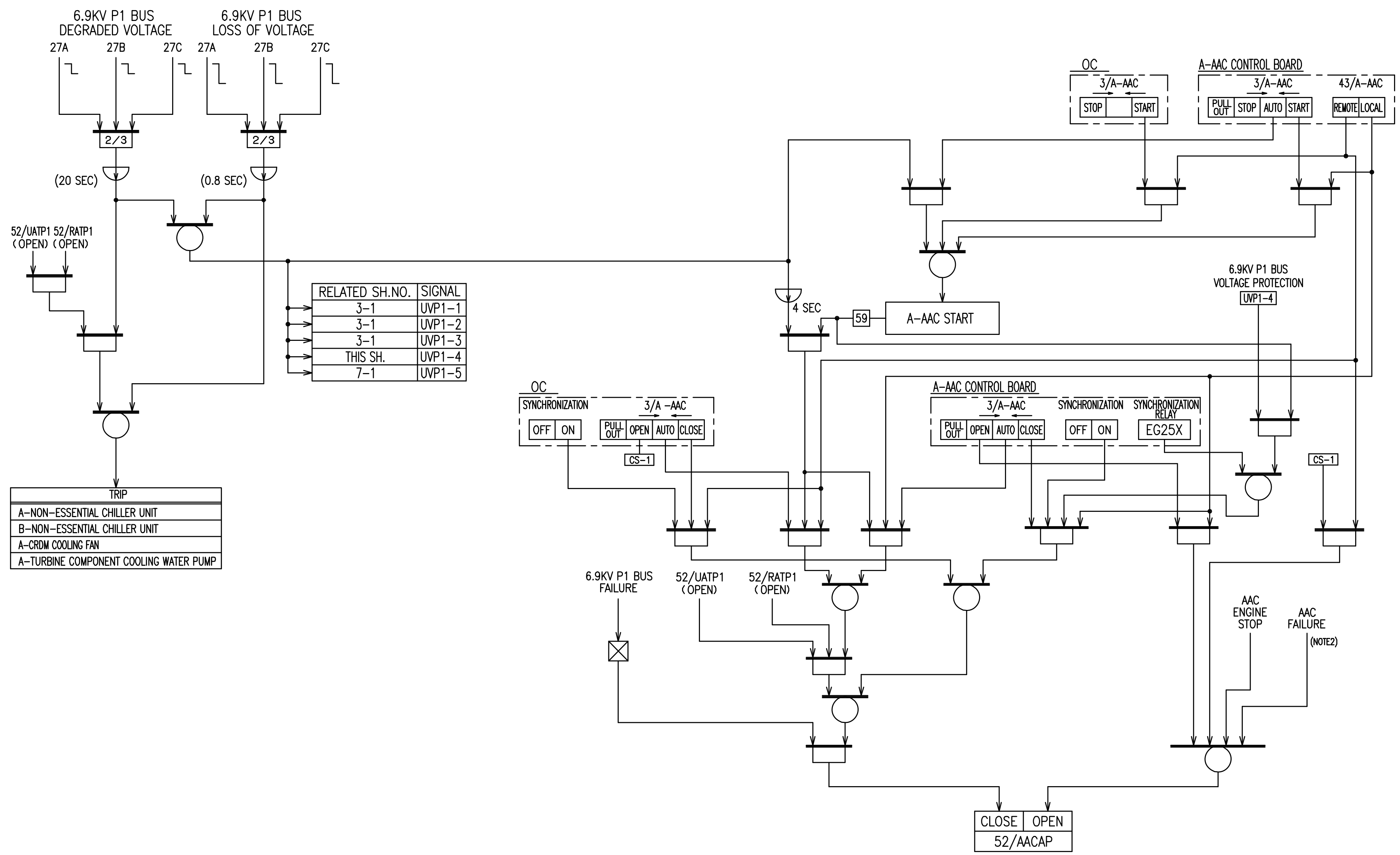


Figure 8.3.1-2 Logic diagrams (Sheet 15 of 24)
D-Class 1E GTG starting initiation and circuit breaker closing

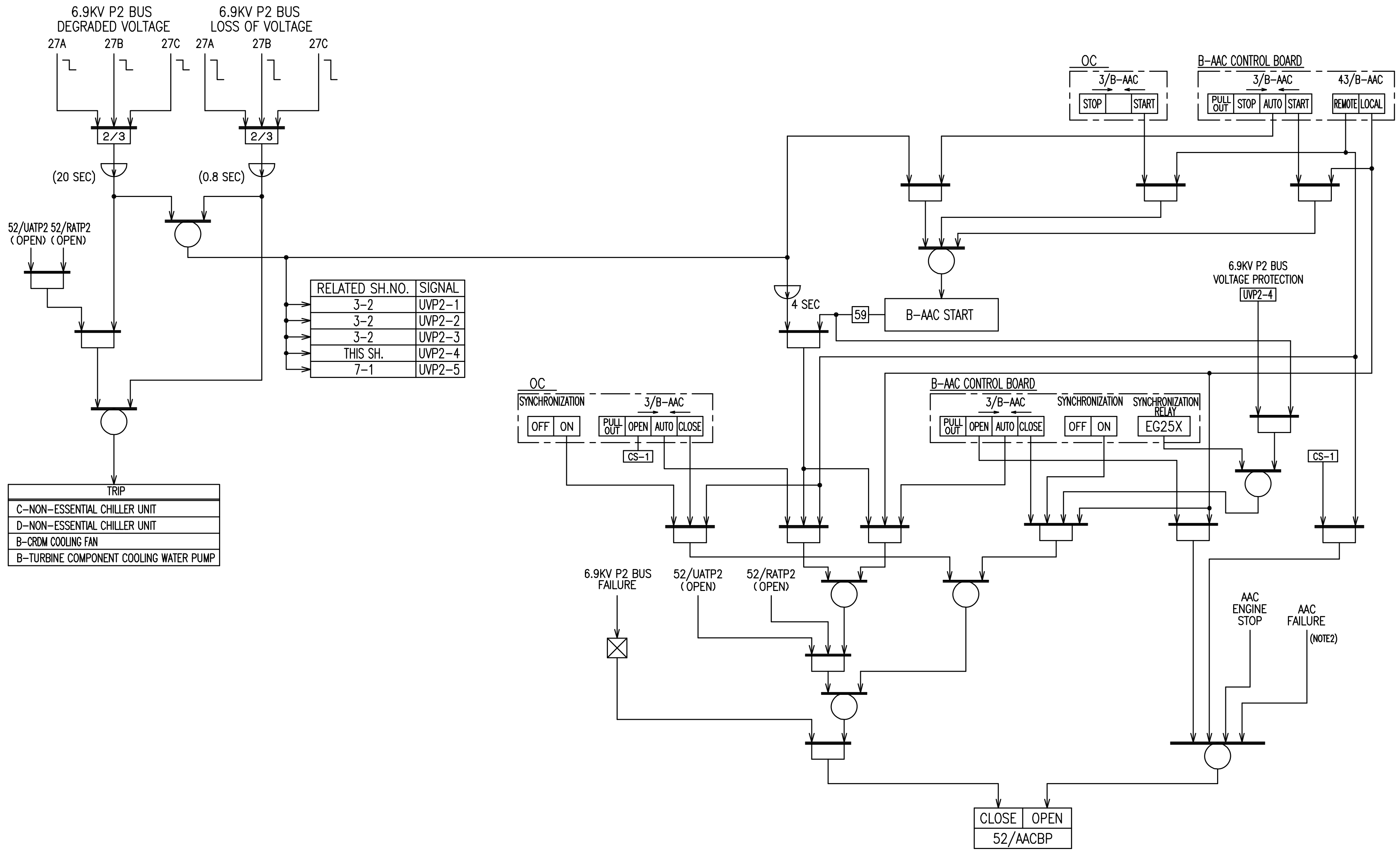


(NOTE1) TRAIN N.

(NOTE2) EXHAUST GAS TEMPERATURE HIGH HIGH, OVERSPEED, START FAILURE, CONTROLLER FAILURE. LUBRICATING OIL TEMPERATURE HIGH HIGH, LUBRICATING OIL PRESSURE LOW.

SH.NO.
5-1

Figure 8.3.1-2 Logic diagrams (Sheet 16 of 24)
A-AAC GTG starting initiation and circuit breaker closing

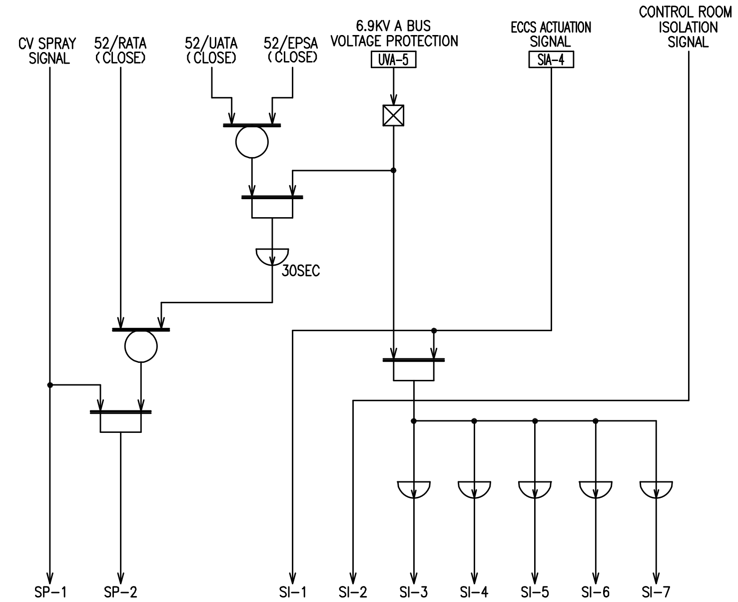


(NOTE1) TRAIN N.

(NOTE2) EXHAUST GAS TEMPERATURE HIGH HIGH, OVERSPEED, START FAILURE, CONTROLLER FAILURE.
LUBRICATING OIL TEMPERATURE HIGH HIGH, LUBRICATING OIL PRESSURE LOW.

SH.NO.
5-2

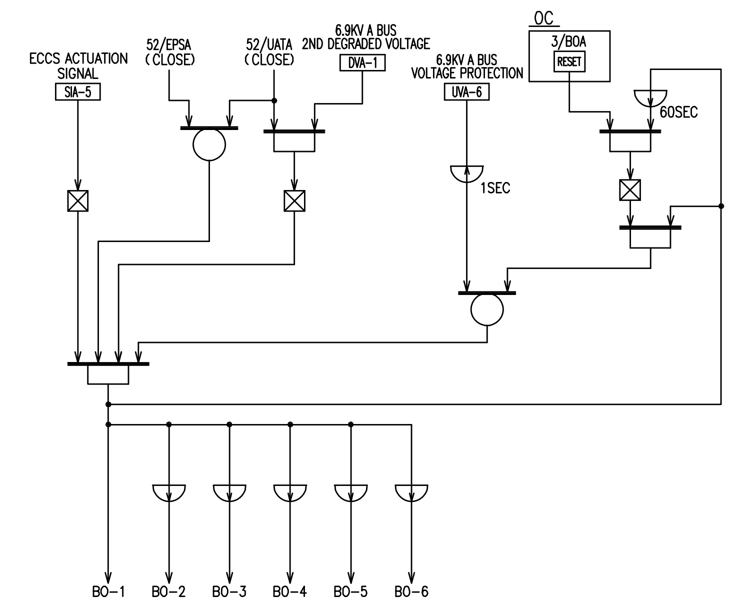
Figure 8.3.1-2 Logic diagrams (Sheet 17 of 24)
B-AAC GTG starting initiation and circuit breaker closing



STEP NO.	NAME	CONNECTED BUS	TIMER SET VALUE	REMARKS	STEP NO.	NAME	CONNECTED BUS	TIMER SET VALUE	REMARKS
SP-1	MOV OPERATED BY SP SIGNAL	MCC(A TRAIN)	——		SI-6	A-CLASS 1E ELECTRICAL ROOM AIR HANDLING UNIT	480V A-BUS	40SEC	(NOTE2)
SP-2	A-CONTAINMENT SPRAY / RESIDUAL HEAT REMOVAL PUMP	6.9KV A-BUS	30SEC		SI-7	A-ESSENTIAL CHILLER UNIT	6.9KV A-BUS	50SEC	
SI-1	MOV OPERATED BY SI SIGNAL MOTOR CONTROL CENTER EQUIPMENT	MCC(A TRAIN) MCC-A,A1	——	※1					
SI-2	MOTOR CONTROL CENTER EQUIPMENT	MCC-A,A1	——	※2					
SI-3	A-SAFETY INJECTION PUMP	6.9KV A-BUS	5SEC						
SI-4	A-COMPONENT COOLING WATER PUMP A-ESSENTIAL CHILLED WATER PUMP	6.9KV A-BUS MCC-A	10SEC						
SI-5	A-ESSENTIAL SERVICE WATER PUMP	6.9KV A-BUS	15SEC						

※ 1	REMARKS
A-ANNULUS EMERGENCY EXHAUST FILTRATION UNIT FAN	
A-ANNULUS EMERGENCY EXHAUST FILTRATION UNIT	
A-SAFEGUARD COMPONENT AREA AIR HANDLING UNIT	(NOTE2)
A-CLASS 1E BATTERY ROOM EXHAUST FAN	
A-EMERGENCY FEED WATER PUMP(T/D) AREA AIR HANDLING UNIT	(NOTE2)

※ 2	REMARKS
A-MAIN CONTROL ROOM AIR HANDLING UNIT	
A-MAIN CONTROL ROOM EMERGENCY FILTRATION UNIT	
A-MAIN CONTROL ROOM EMERGENCY FILTRATION UNIT FAN	



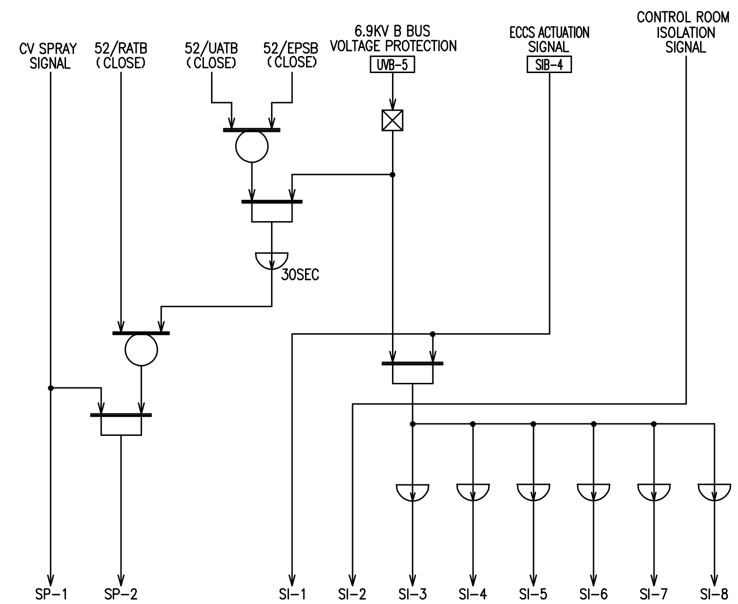
STEP NO.	NAME	CONNECTED BUS	TIMER SET VALUE	REMARKS
BO-1	MOTOR CONTROL CENTER EQUIPMENT	MCC-A	——	※3
BO-2	A-CHARGING PUMP	6.9KV A-BUS	5SEC	
BO-3	A-COMPONENT COOLING WATER PUMP	6.9KV A-BUS	10SEC	
BO-4	A-ESSENTIAL SERVICE WATER PUMP A-ESSENTIAL CHILLED WATER PUMP	6.9KV A-BUS MCC-A	15SEC	
BO-5	A-CLASS 1E ELECTRICAL ROOM AIR HANDLING UNIT	480V A-BUS	30SEC	(NOTE2)
BO-6	A-ESSENTIAL CHILLER UNIT	6.9KV A-BUS	40SEC	

※ 3	REMARKS
A-MAIN CONTROL ROOM AIR HANDLING UNIT	(NOTE2)
A-SAFEGUARD COMPONENT AREA AIR HANDLING UNIT	(NOTE2)
A-CLASS 1E BATTERY ROOM EXHAUST FAN	
A-EMERGENCY FEED WATER PUMP(T/D) AREA AIR HANDLING UNIT	(NOTE2)

(NOTE1) TRAIN A
(NOTE2) HANDLING UNITS HAVE A FAN AND A REHEATING COIL. AFTER STARTING SIGNAL RECEIVING A FAN STARTS AND A REHEATING UNITS STARTS IF AREA TEMPERATURE MAKES SET VALUE.

SH.NO. 6-1

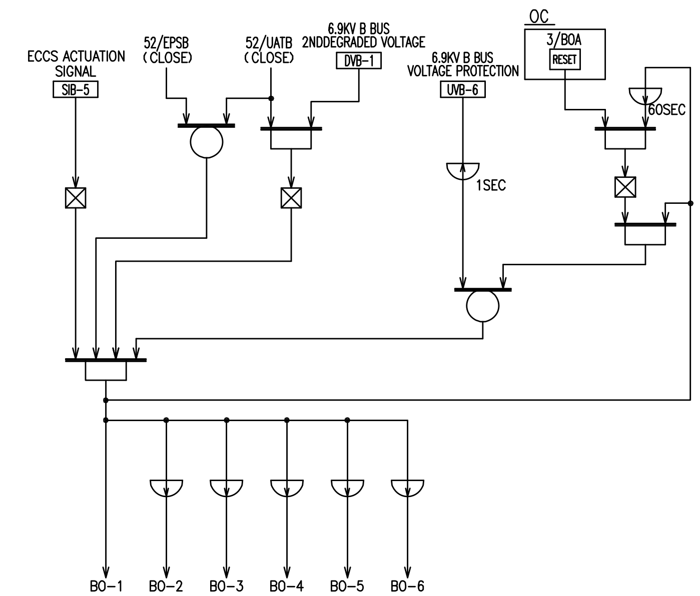
Figure 8.3.1-2 Logic diagrams (Sheet 18 of 24)
Class 1E train A LOOP and LOCA load sequencing



STEP NO.	NAME	CONNECTED BUS	TIMER SET VALUE	REMARKS	STEP NO.	NAME	CONNECTED BUS	TIMER SET VALUE	REMARKS
SP-1	MOV OPERATED BY SP SIGNAL	MCC(B TRAIN)	——		SI-6	B-EMERGENCY FEED WATER PUMP	6.9KV B-BUS	20SEC	
SP-2	B-CONTAINMENT SPRAY / RESIDUAL HEAT REMOVAL PUMP	6.9KV B-BUS	30SEC		SI-7	B-CLASS 1E ELECTRICAL ROOM AIR HANDLING UNIT	480V B-BUS	40SEC	(NOTE2)
SI-1	MOV OPERATED BY SI SIGNAL MOTOR CONTROL CENTER EQUIPMENT	MCC(B TRAIN) MCC-B,A1	——	※1	SI-8	B-ESSENTIAL CHILLER UNIT	6.9KV B-BUS	50SEC	
SI-2	MOTOR CONTROL CENTER EQUIPMENT	MCC-B,A1	——	※2					
SI-3	B-SAFETY INJECTION PUMP	6.9KV B-BUS	5SEC						
SI-4	B-COMPONENT COOLING WATER PUMP B-ESSENTIAL CHILLED WATER PUMP	6.9KV B-BUS MCC-B	10SEC						
SI-5	B-ESSENTIAL SERVICE WATER PUMP	6.9KV B-BUS	15SEC						

※ 1	REMARKS
B-SAFEGUARD COMPONENT AREA AIR HANDLING UNIT	(NOTE2)
B-CLASS 1E BATTERY ROOM EXHAUST FAN	
B-EMERGENCY FEED WATER PUMP(M/D) AREA AIR HANDLING UNIT	(NOTE2)

※ 2	REMARKS
B-MAIN CONTROL ROOM AIR HANDLING UNIT	



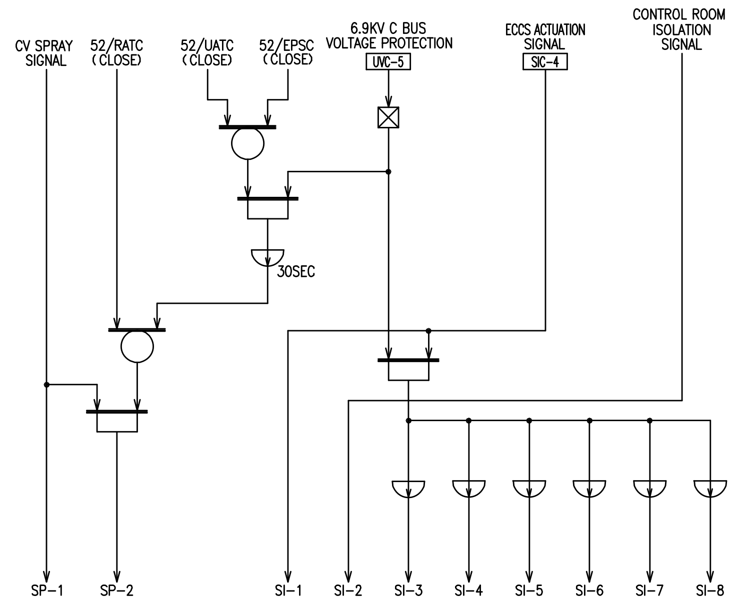
STEP NO.	NAME	CONNECTED BUS	TIMER SET VALUE	REMARKS
BO-1	MOTOR CONTROL CENTER EQUIPMENT	MCC-B	——	※3
BO-2	B-COMPONENT COOLING WATER PUMP	6.9KV B-BUS	10SEC	
BO-3	B-ESSENTIAL SERVICE WATER PUMP B-ESSENTIAL CHILLED WATER PUMP	6.9KV B-BUS MCC-B	15SEC	
BO-4	B-EMERGENCY FEED WATER PUMP	6.9KV B-BUS	20SEC	
BO-5	B-CLASS 1E ELECTRICAL ROOM AIR HANDLING UNIT	480V B-BUS	30SEC	(NOTE2)
BO-6	B-ESSENTIAL CHILLER UNIT	6.9KV B-BUS	40SEC	

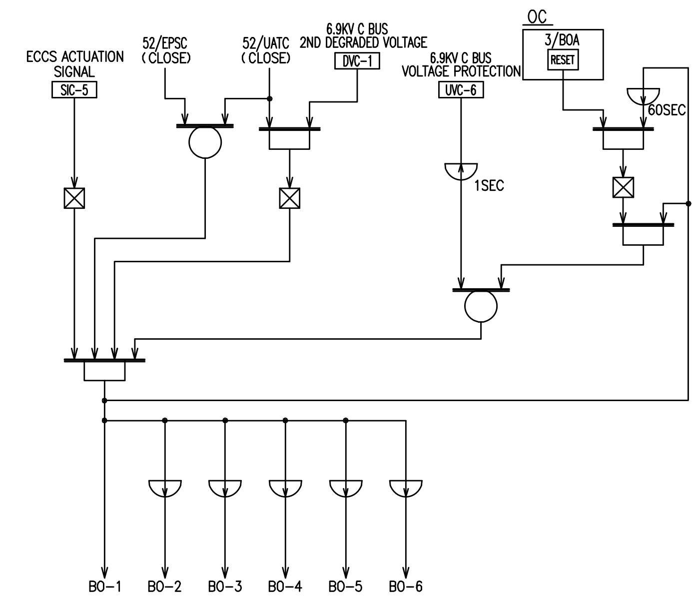
※ 3	REMARKS
B-MAIN CONTROL ROOM AIR HANDLING UNIT	(NOTE2)
B-SAFEGUARD COMPONENT AREA AIR HANDLING UNIT	(NOTE2)
B-CLASS 1E BATTERY ROOM EXHAUST FAN	
B-EMERGENCY FEED WATER PUMP(M/D) AREA AIR HANDLING UNIT	(NOTE2)

(NOTE1) TRAIN B
(NOTE2) HANDLING UNITS HAVE A FAN AND A REHEATING COIL. AFTER STARTING SIGNAL RECEIVING A FAN STARTS AND A REHEATING UNITS STARTS IF AREA TEMPERATURE MAKES SET VALUE.

SH.NO.
6-2

Figure 8.3.1-2 Logic diagrams (Sheet 19 of 24)
Class 1E train B LOOP and LOCA load sequencing





STEP NO.	NAME	CONNECTED BUS	TIMER SET VALUE	REMARKS	STEP NO.	NAME	CONNECTED BUS	TIMER SET VALUE	REMARKS
SP-1	MOV OPERATED BY SP SIGNAL	MCC(C TRAIN)	—		SI-6	C-EMERGENCY FEED WATER PUMP	6.9KV C-BUS	20SEC	
SP-2	C-CONTAINMENT SPRAY / RESIDUAL HEAT REMOVAL PUMP	6.9KV C-BUS	30SEC		SI-7	C-CLASS 1E ELECTRICAL ROOM AIR HANDLING UNIT	480V C-BUS	40SEC	(NOTE2)
SI-1	MOV OPERATED BY SI SIGNAL MOTOR CONTROL CENTER EQUIPMENT	MCC(C TRAIN) MCC-C,D1	—	※1	SI-8	C-ESSENTIAL CHILLER UNIT	6.9KV C-BUS	50SEC	
SI-2	MOTOR CONTROL CENTER EQUIPMENT	MCC-C,D1	—	※2					
SI-3	C-SAFETY INJECTION PUMP	6.9KV C-BUS	5SEC						
SI-4	C-COMPONENT COOLING WATER PUMP C-ESSENTIAL CHILLED WATER PUMP	6.9KV C-BUS MCC-C	10SEC						
SI-5	C-ESSENTIAL SERVICE WATER PUMP	6.9KV C-BUS	15SEC						

STEP NO.	NAME	CONNECTED BUS	TIMER SET VALUE	REMARKS
BO-1	MOTOR CONTROL CENTER EQUIPMENT	MCC-C	—	※3
BO-2	C-COMPONENT COOLING WATER PUMP	6.9KV C-BUS	10SEC	
BO-3	C-ESSENTIAL SERVICE WATER PUMP C-ESSENTIAL CHILLED WATER PUMP	6.9KV C-BUS MCC-C	15SEC	
BO-4	C-EMERGENCY FEED WATER PUMP	6.9KV C-BUS	20SEC	
BO-5	C-CLASS 1E ELECTRICAL ROOM AIR HANDLING UNIT	480V C-BUS	30SEC	(NOTE2)
BO-6	C-ESSENTIAL CHILLER UNIT	6.9KV C-BUS	40SEC	

※ 1	REMARKS
C-SAFEGUARD COMPONENT AREA AIR HANDLING UNIT	(NOTE2)
C-CLASS 1E BATTERY ROOM EXHAUST FAN	
C-EMERGENCY FEED WATER PUMP(M/D) AREA AIR HANDLING UNIT	(NOTE2)

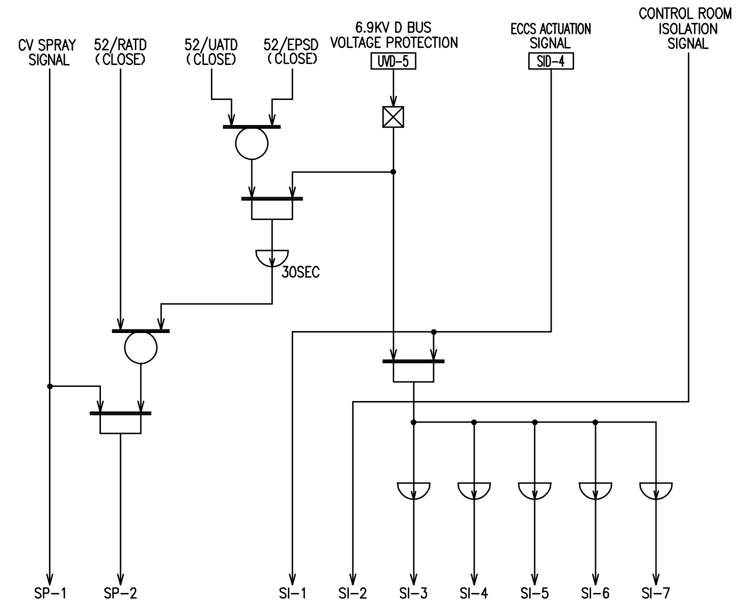
※ 2	REMARKS
C-MAIN CONTROL ROOM AIR HANDLING UNIT	

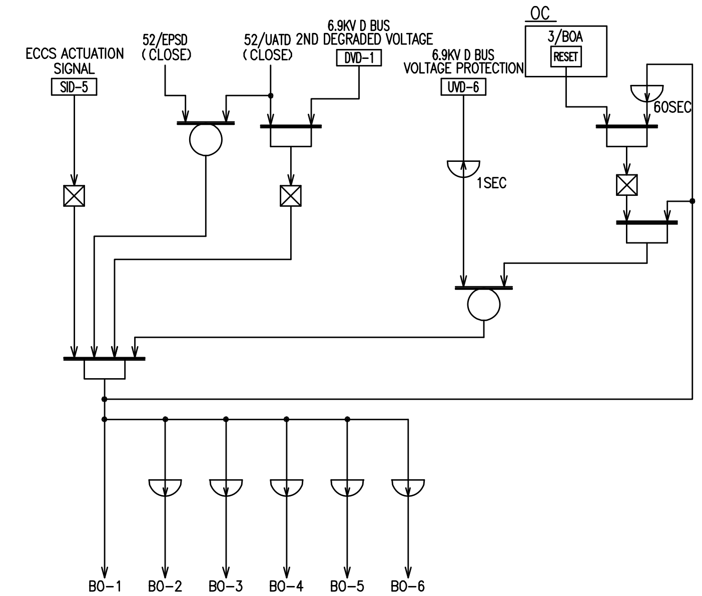
※ 3	REMARKS
C-MAIN CONTROL ROOM AIR HANDLING UNIT	(NOTE2)
C-SAFEGUARD COMPONENT AREA AIR HANDLING UNIT	(NOTE2)
C-CLASS 1E BATTERY ROOM EXHAUST FAN	
C-EMERGENCY FEED WATER PUMP(M/D) AREA AIR HANDLING UNIT	(NOTE2)

(NOTE1) TRAIN C
(NOTE2) HANDLING UNITS HAVE A FAN AND A REHEATING COIL. AFTER STARTING SIGNAL RECEIVING A FAN STARTS AND A REHEATING UNITS STARTS IF AREA TEMPERATURE MAKES SET VALUE.

SH.NO. 6-3

Figure 8.3.1-2 Logic diagrams (Sheet 20 of 24)
Class 1E train C LOOP and LOCA load sequencing





STEP NO.	NAME	CONNECTED BUS	TIMER SET VALUE	REMARKS	STEP NO.	NAME	CONNECTED BUS	TIMER SET VALUE	REMARKS
SP-1	MOV OPERATED BY SP SIGNAL	MCC(D TRAIN)	—		SI-6	D-CLASS 1E ELECTRICAL ROOM AIR HANDLING UNIT	480V D-BUS	40SEC	(NOTE2)
SP-2	D-CONTAINMENT SPRAY / RESIDUAL HEAT REMOVAL PUMP	6.9KV D-BUS	30SEC		SI-7	D-ESSENTIAL CHILLER UNIT	6.9KV D-BUS	50SEC	
SI-1	MOV OPERATED BY SI SIGNAL MOTOR CONTROL CENTER EQUIPMENT	MCC(D TRAIN) MCC-D,D1	—	※1					
SI-2	MOTOR CONTROL CENTER EQUIPMENT	MCC-D,D1	—	※2					
SI-3	D-SAFETY INJECTION PUMP	6.9KV D-BUS	5SEC						
SI-4	D-COMPONENT COOLING WATER PUMP D-ESSENTIAL CHILLED WATER PUMP	6.9KV D-BUS MCC-D	10SEC						
SI-5	D-ESSENTIAL SERVICE WATER PUMP	6.9KV D-BUS	15SEC						

STEP NO.	NAME	CONNECTED BUS	TIMER SET VALUE	REMARKS
BO-1	MOTOR CONTROL CENTER EQUIPMENT	MCC-D	—	※3
BO-2	B-CHARGING PUMP	6.9KV D-BUS	5SEC	
BO-3	D-COMPONENT COOLING WATER PUMP	6.9KV D-BUS	10SEC	
BO-4	D-ESSENTIAL SERVICE WATER PUMP D-ESSENTIAL CHILLED WATER PUMP	6.9KV D-BUS MCC-D	15SEC	
BO-5	D-CLASS 1E ELECTRICAL ROOM AIR HANDLING UNIT	480V D-BUS	30SEC	(NOTE2)
BO-6	D-ESSENTIAL CHILLER UNIT	6.9KV D-BUS	40SEC	

※ 1	REMARKS
B-ANNULUS EMERGENCY EXHAUST FILTRATION UNIT FAN	
B-ANNULUS EMERGENCY EXHAUST FILTRATION UNIT	
D-SAFEGUARD COMPONENT AREA AIR HANDLING UNIT	(NOTE2)
D-CLASS 1E BATTERY ROOM EXHAUST FAN	
D-EMERGENCY FEED WATER PUMP(T/D) AREA AIR HANDLING UNIT	(NOTE2)

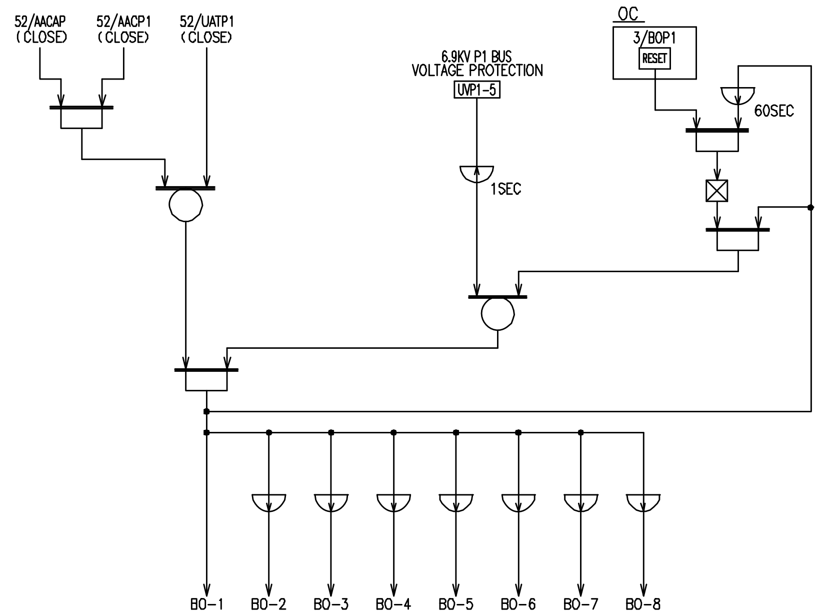
※ 2	REMARKS
D-MAIN CONTROL ROOM AIR HANDLING UNIT	
D-MAIN CONTROL ROOM EMERGENCY FILTRATION UNIT	
D-MAIN CONTROL ROOM EMERGENCY FILTRATION UNIT FAN	

※ 3	REMARKS
D-MAIN CONTROL ROOM AIR HANDLING UNIT	(NOTE2)
D-SAFEGUARD COMPONENT AREA AIR HANDLING UNIT	(NOTE2)
D-CLASS 1E BATTERY ROOM EXHAUST FAN	
D-EMERGENCY FEED WATER PUMP(T/D) AREA AIR HANDLING UNIT	(NOTE2)

(NOTE1) TRAIN D
(NOTE2) HANDLING UNITS HAVE A FAN AND A REHEATING COIL. AFTER STARTING SIGNAL RECEIVING A FAN STARTS AND A REHEATING UNITS STARTS IF AREA TEMPERATURE MAKES SET VALUE.

SH.NO.
6-4

Figure 8.3.1-2 Logic diagrams (Sheet 21 of 24)
Class 1E train D LOOP and LOCA load sequencing

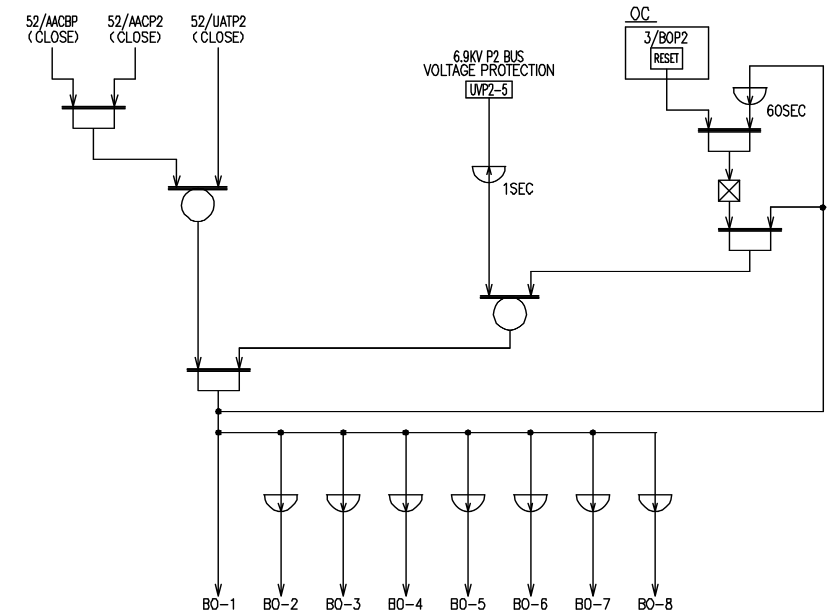


STEP NO.	NAME	CONNECTED BUS	TIMER SET VALUE	REMARKS	STEP NO.	NAME	CONNECTED BUS	TIMER SET VALUE	REMARKS
BO-1	MOTOR CONTROL CENTER EQUIPMENT	MCC-P11	——	※1	BO-8	B-TURBINE COMPONENT COOLING WATER PUMP	6.9KV P1-BUS	40SEC	
BO-2	A-INSTRUMENT AIR COMPRESSOR	480V P12-BUS	5SEC						
BO-3	A-NON-ESSENTIAL CHILLED WATER PUMP MOTOR CONTROL CENTER EQUIPMENT	480V P11-BUS MCC P11-BUS	10SEC	※2					
BO-4	MOTOR CONTROL CENTER EQUIPMENT	MCC P11-BUS	15SEC	※3					
BO-5	A-NON-ESSENTIAL CHILLER UNIT	6.9KV P1-BUS	20SEC						
BO-6	A-CRDM COOLING FAN	6.9KV P1-BUS	30SEC						
BO-7	A-REACTOR CAVITY COOLING FAN	480V P11-BUS	35SEC						

※ 1	REMARKS
A-NON-CLASS 1E BATTERY ROOM EXHAUST FAN	

※ 2	REMARKS
A-NON-ESSENTIAL CHILLED WATER SYSTEM COOLING TOWER FAN	
A-NON-ESSENTIAL CHILLED WATER SYSTEM CONDENSER WATER PUMP	

※ 3	REMARKS
A-CONTAINMENT FAN COOLER UNIT FAN	
A-NON-CLASS 1E ELECTRICAL ROOM AIR HANDLING UNIT FAN	
A-NON-CLASS 1E ELECTRICAL ROOM RETURN AIR FAN	



STEP NO.	NAME	CONNECTED BUS	TIMER SET VALUE	REMARKS	STEP NO.	NAME	CONNECTED BUS	TIMER SET VALUE	REMARKS
BO-1	MOTOR CONTROL CENTER EQUIPMENT	MCC-P21	——	※4	BO-8	C-TURBINE COMPONENT COOLING WATER PUMP	6.9KV P2-BUS	40SEC	
BO-2	B-INSTRUMENT AIR COMPRESSOR	480V P22-BUS	5SEC						
BO-3	B-NON-ESSENTIAL CHILLED WATER PUMP MOTOR CONTROL CENTER EQUIPMENT	480V P21-BUS MCC P21-BUS	10SEC	※5					
BO-4	MOTOR CONTROL CENTER EQUIPMENT	MCC P21-BUS	15SEC	※6					
BO-5	B-NON-ESSENTIAL CHILLER UNIT	6.9KV P2-BUS	20SEC						
BO-6	B-CRDM COOLING FAN	6.9KV P2-BUS	30SEC						
BO-7	B-REACTOR CAVITY COOLING FAN	480V P21-BUS	35SEC						

※ 4	REMARKS
B-NON-CLASS 1E BATTERY ROOM EXHAUST FAN	

※ 5	REMARKS
C-NON-ESSENTIAL CHILLED WATER SYSTEM COOLING TOWER FAN	
C-NON-ESSENTIAL CHILLED WATER SYSTEM CONDENSER WATER PUMP	

※ 6	REMARKS
C-CONTAINMENT FAN COOLER UNIT FAN	
B-NON-CLASS 1E ELECTRICAL ROOM AIR HANDLING UNIT FAN	
B-NON-CLASS 1E ELECTRICAL ROOM RETURN AIR FAN	

(NOTE1) TRAIN N

SH.NO.
7-1

Figure 8.3.1-2 Logic diagrams (Sheet 22 of 24)
Non-Class 1E permanent bus P1 and P2 LOOP load sequencing

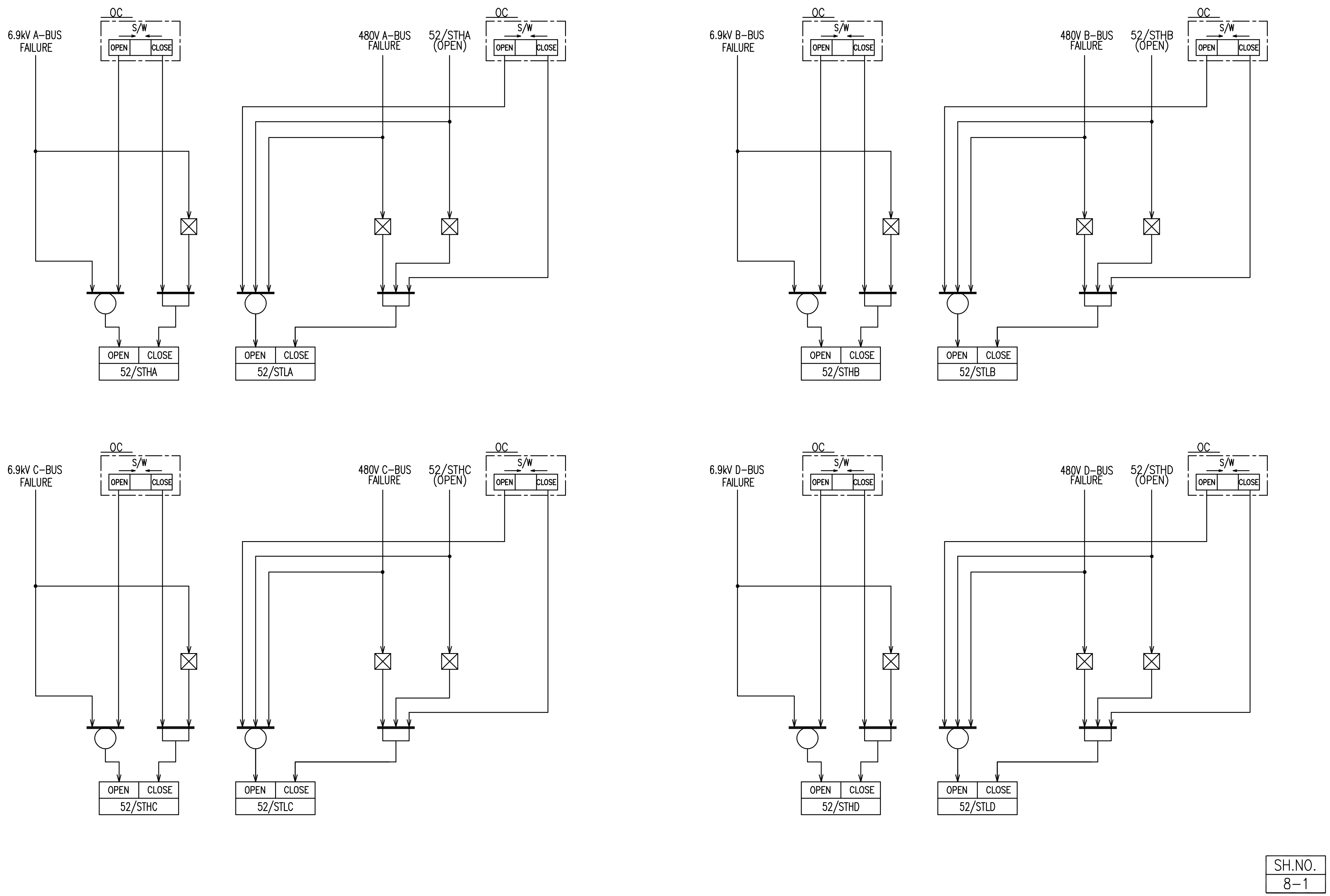


Figure 8.3.1-2 Logic diagrams (Sheet 23 of 24)
Class 1E 480V bus A, B, C and D incoming circuit breaker tripping and closing

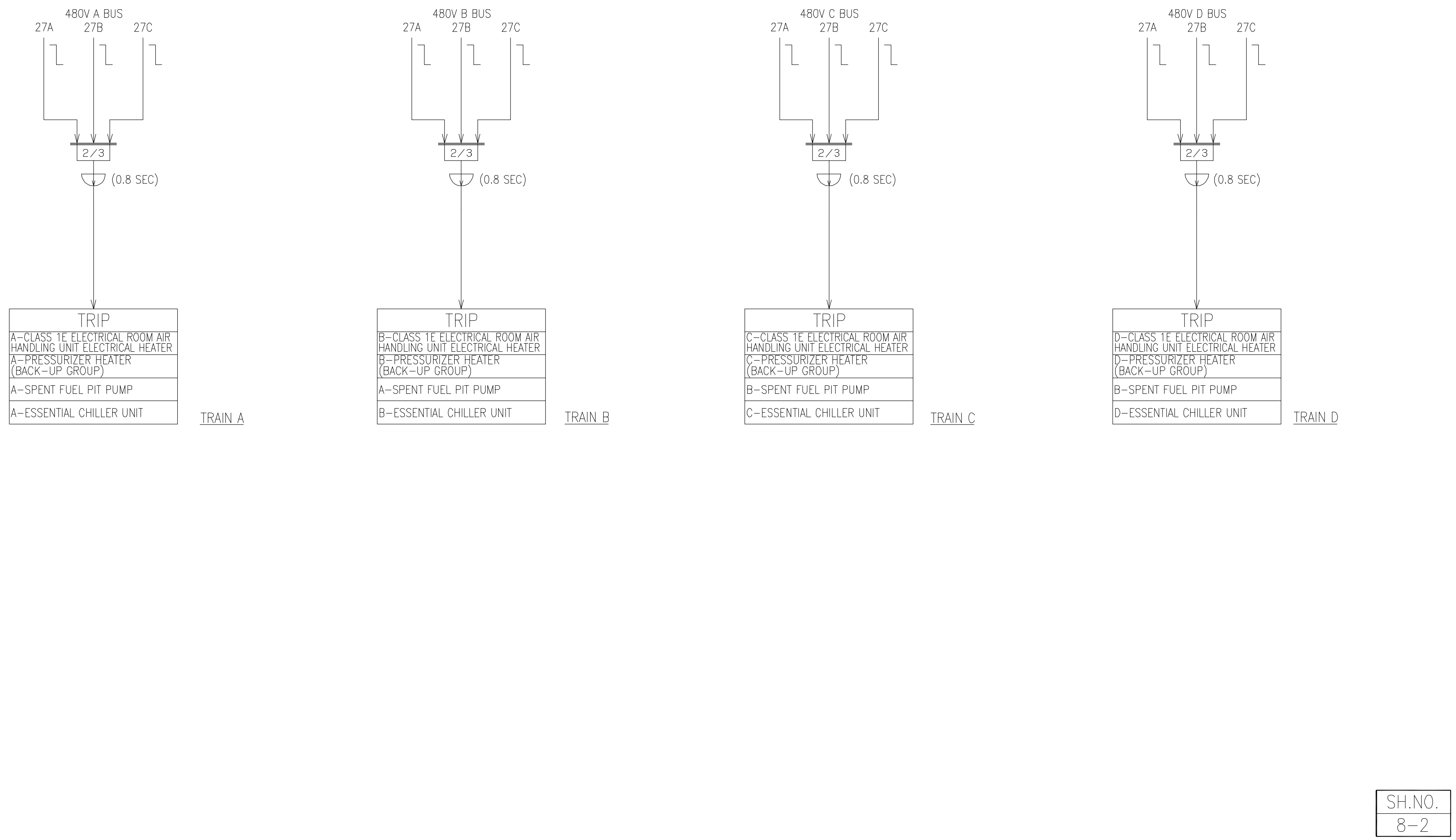


Figure 8.3.1-2 Logic diagrams (Sheet 24 of 24)
Class 1E 480V bus A, B, C and D load shedding

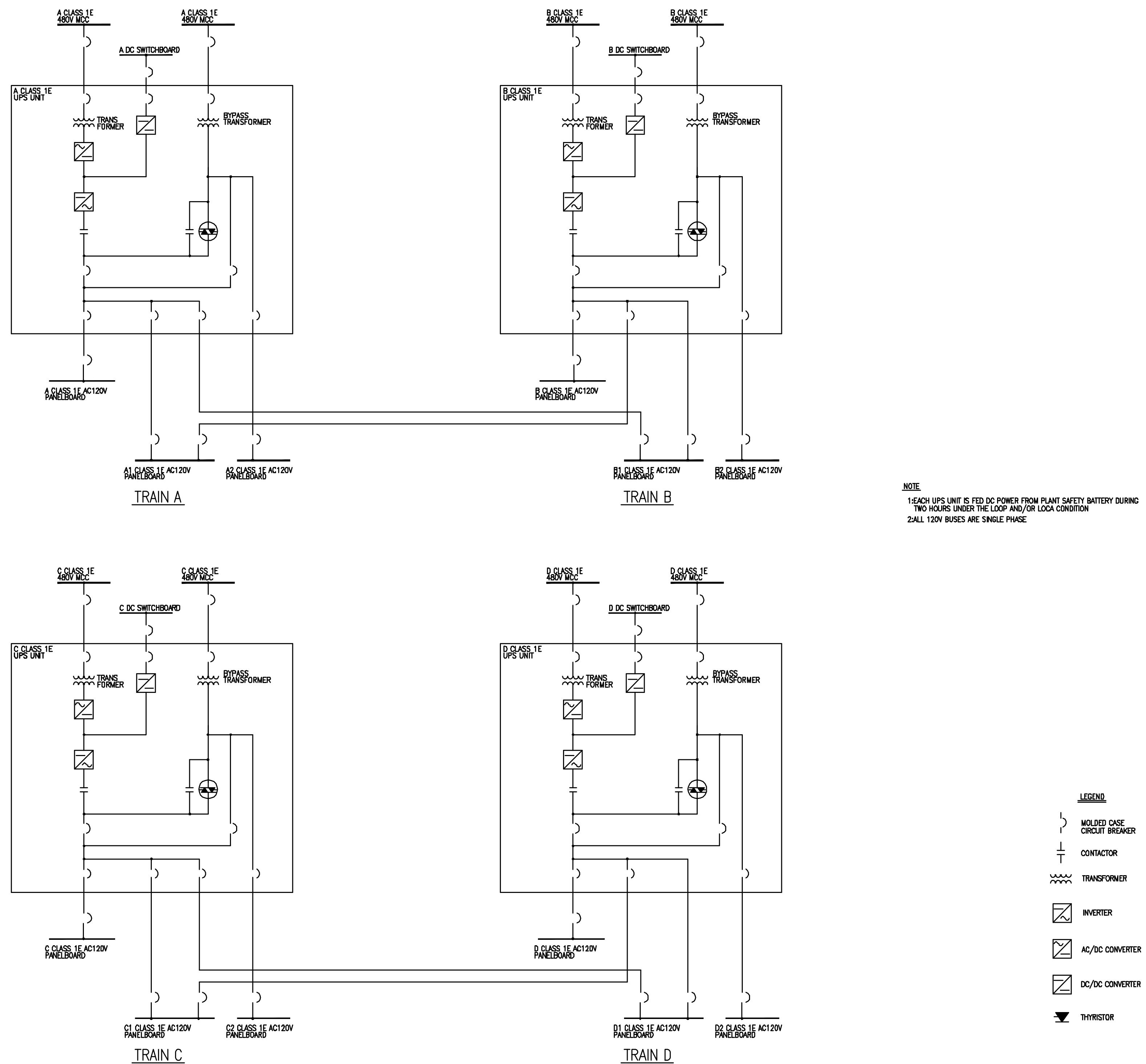


Figure 8.3.1-3 120V AC I&C power supply panels (Sheet 1 of 2) Class 1E

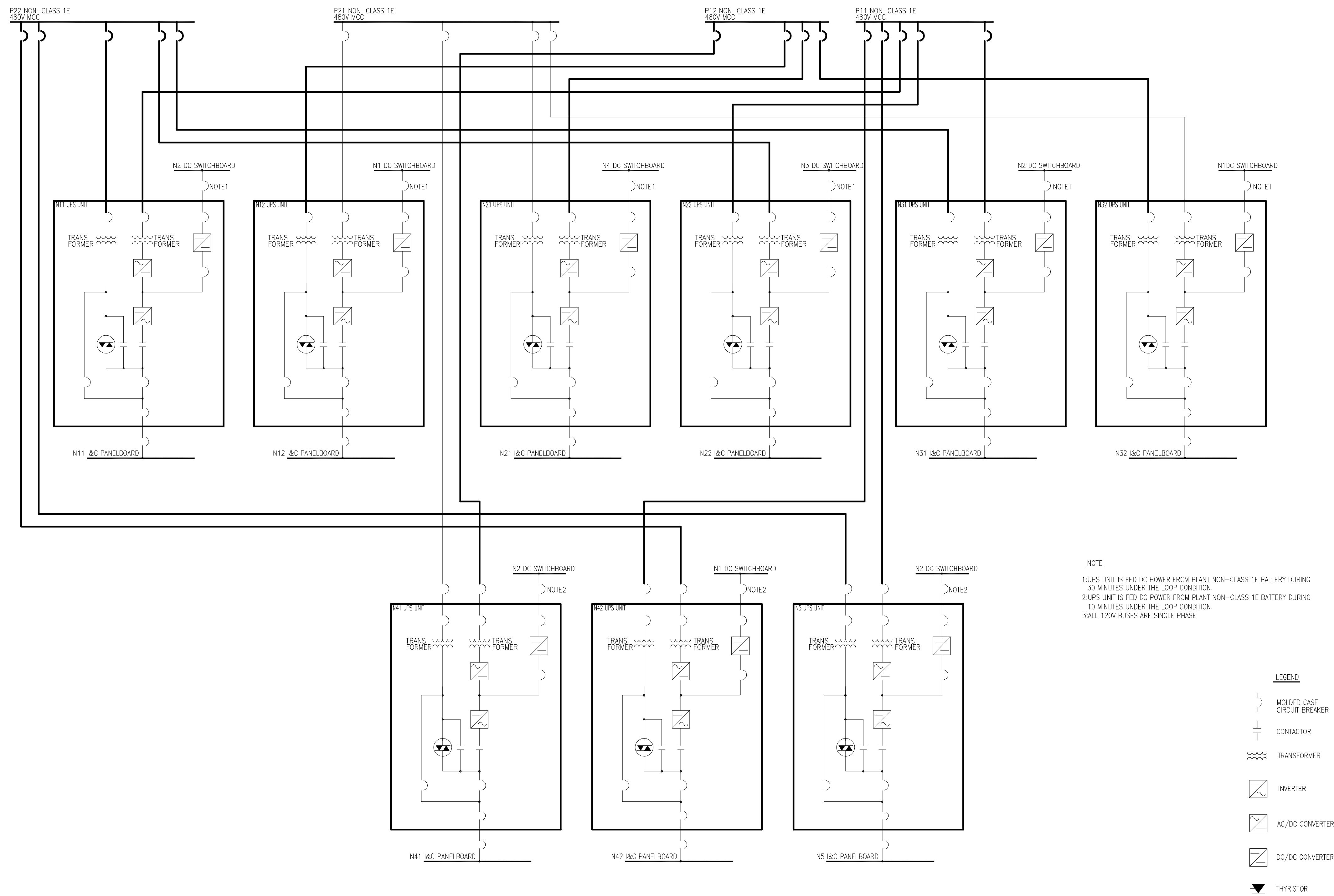


Figure 8.3.1-3 120V AC I&C power supply panels (Sheet 2 of 2) Non-Class 1E

Security-Related Information – Withheld Under 10 CFR 2.390

Figure 8.3.1-4 Class 1E electrical equipment layout (Sheet 1 of 5)
EL. -26’ -4”

Security-Related Information – Withheld Under 10 CFR 2.390

Figure 8.3.1-4 Class 1E electrical equipment layout (Sheet 2 of 5)
EL. -8' -7"

Security-Related Information – Withheld Under 10 CFR 2.390

Figure 8.3.1-4 Class 1E electrical equipment layout (Sheet 3 of 5)
EL. 3' -7"

Security-Related Information – Withheld Under 10 CFR 2.390

Figure 8.3.1-4 Class 1E electrical equipment layout (Sheet 4 of 5)
EL. 25’ -3”

Security-Related Information – Withheld Under 10 CFR 2.390

Figure 8.3.1-4 Class 1E electrical equipment layout (Sheet 5 of 5)
EL. 76' -5"

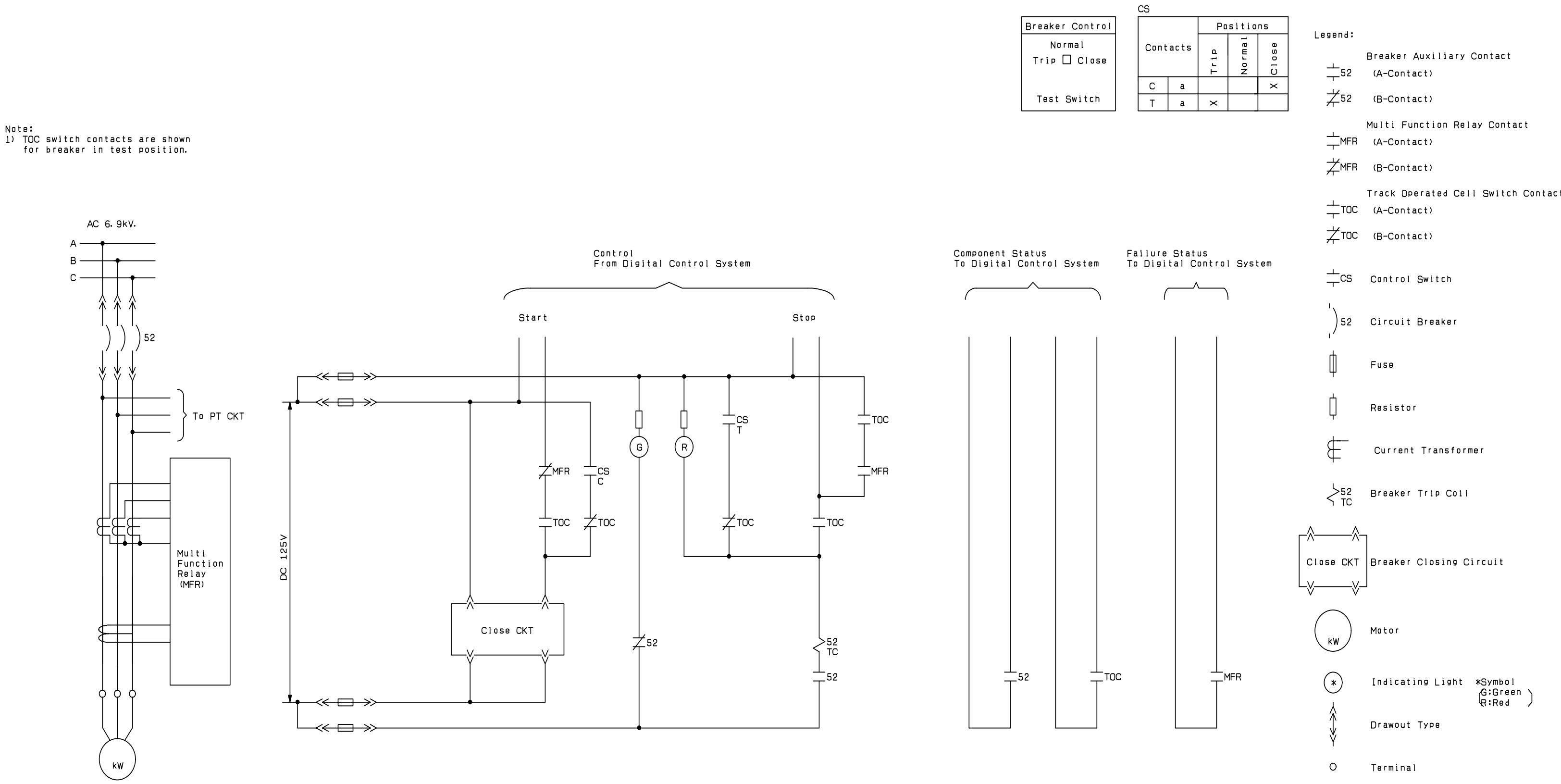


Figure 8.3.1-5 Typical Schematic Diagrams (Sheet 1 of 5)
6.9kV Switchgear

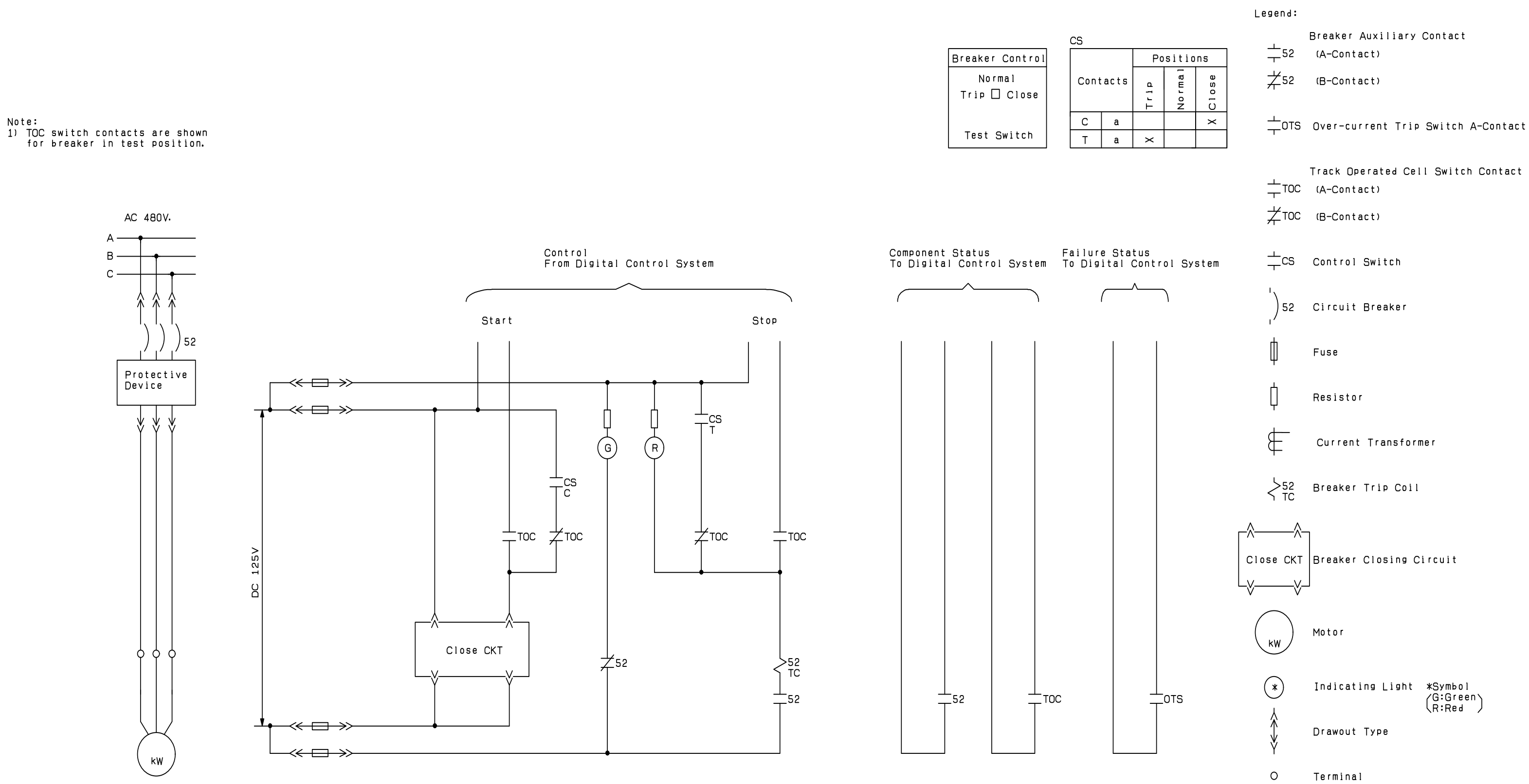


**Figure 8.3.1-5 Typical Schematic Diagrams (Sheet 2 of 5)
480V Load Center**

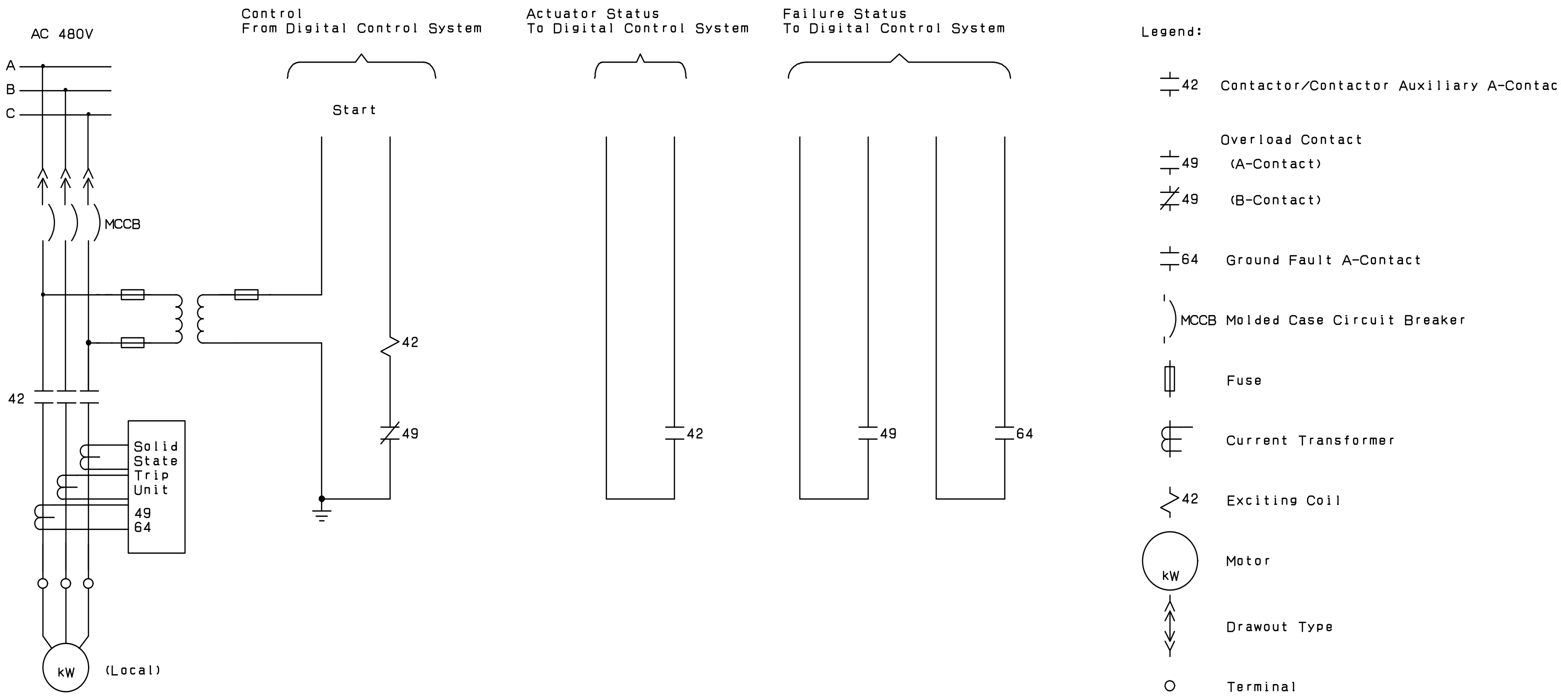


Figure 8.3.1-5 Typical Schematic Diagrams (Sheet 3 of 5)
480V Motor Control Center

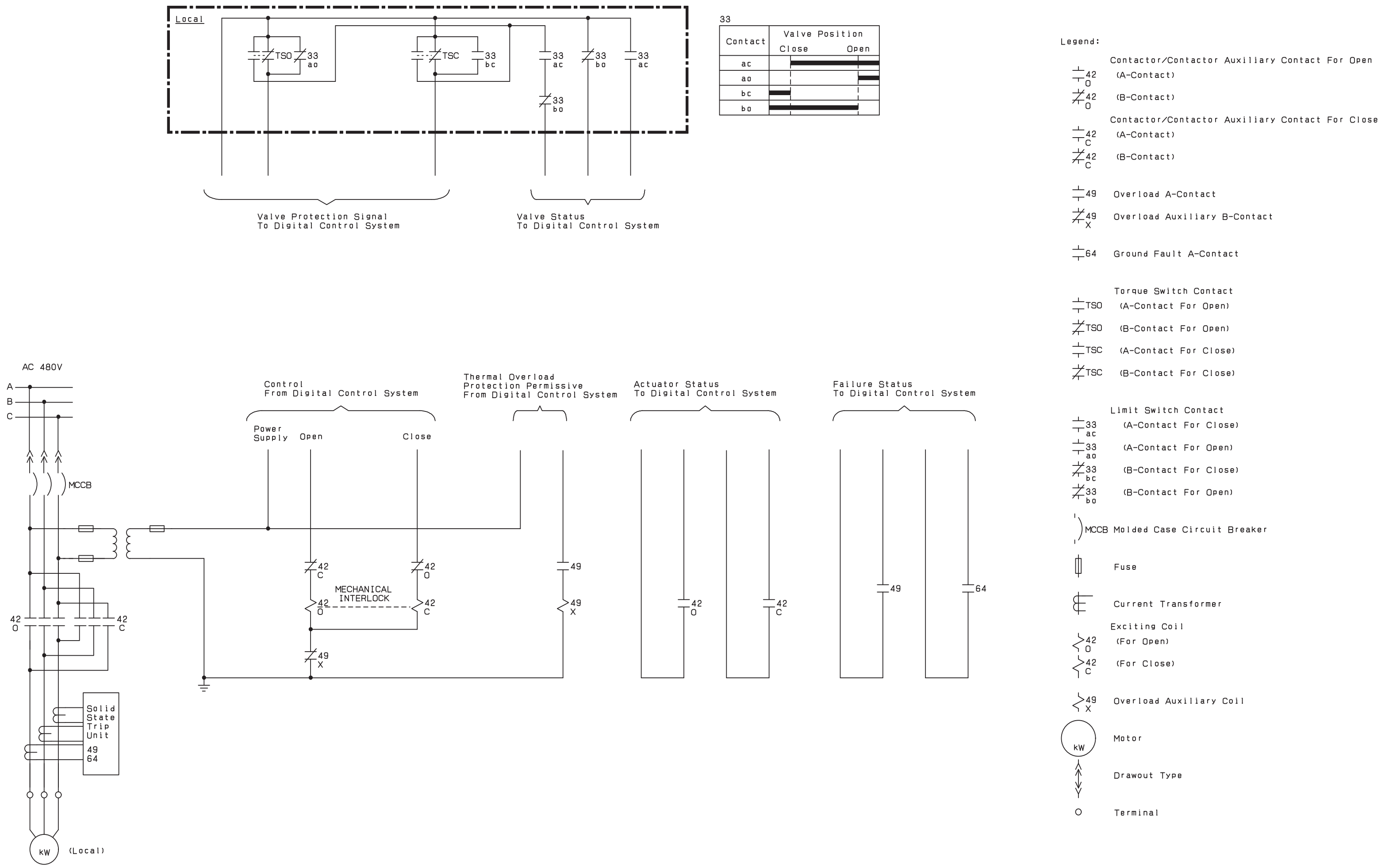


Figure 8.3.1-5 Typical Schematic Diagram (Sheet 4 of 5)
Motor Operated Valve

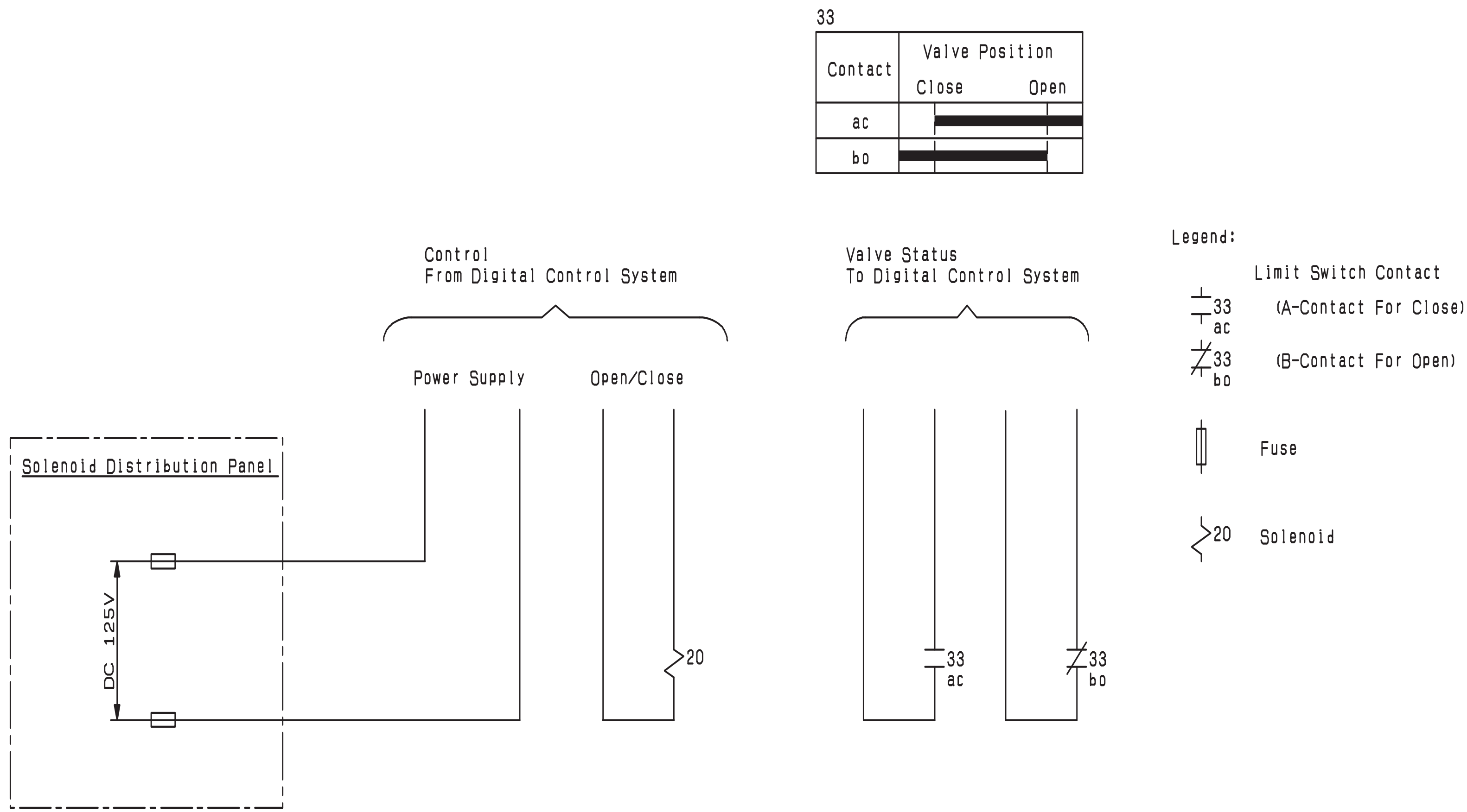


Figure 8.3.1-5 Typical Schematic Diagram (Sheet 5 of 5)
Solenoid Valve

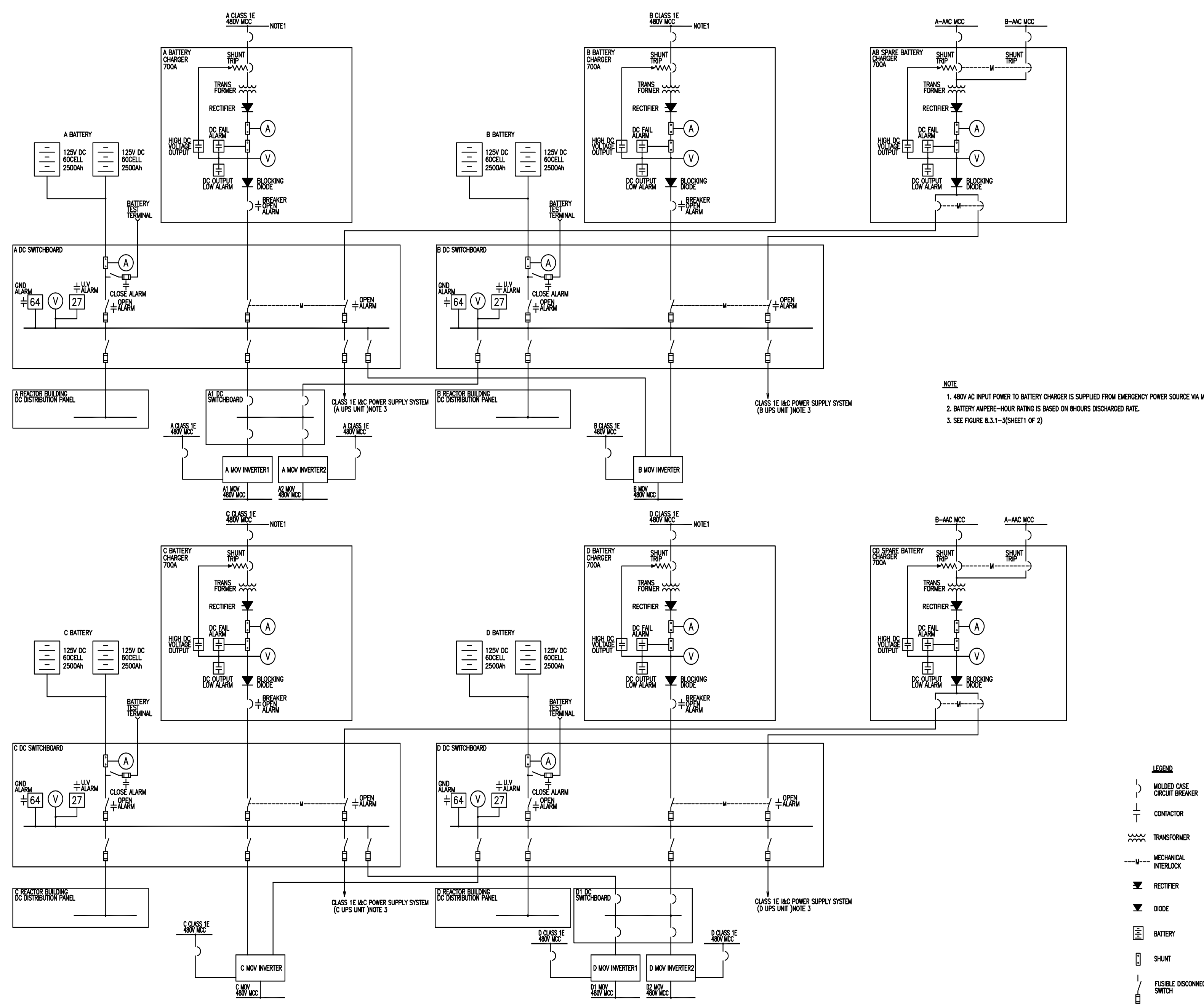


Figure 8.3.2-1 DC Power Distribution System (Sheet 1 of 2)
Class 1E

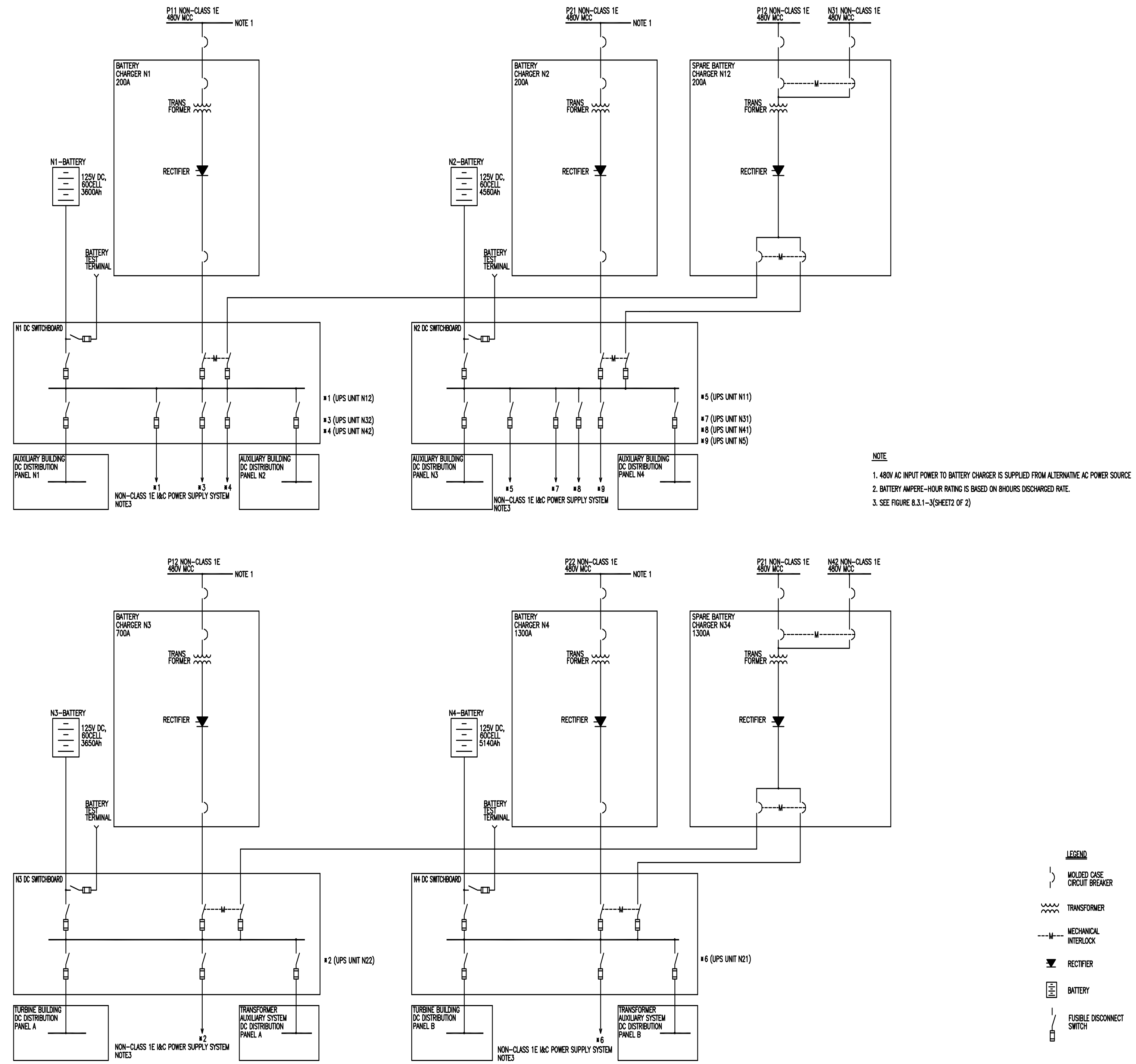


Figure 8.3.2-1 DC Power Distribution System (Sheet 2 of 2)
Non-Class 1E

8.4 Station Blackout

8.4.1 Description

8.4.1.1 Regulatory Requirements

10 CFR 50.63 (Reference 8.2-5) "Loss of All Alternating Current Power" (SBO rule) requires the following:

1. Each light-water-cooled nuclear power plant licensed to operate must be able to withstand for a specified duration and recover from an SBO as defined in 10 CFR 50.2 (Reference 8.2-13). The specified station blackout duration shall be based on the following factors:

    - The redundancy of the onsite emergency ac power sources
    - The reliability of the onsite emergency ac power sources
    - The expected frequency of loss of offsite ac power source
    - The probable time needed to restore offsite power

2. The reactor core and associated coolant, control, and protection systems, including station batteries and any other necessary support systems, must provide sufficient capacity and capability to ensure that the core is cooled and that the appropriate containment integrity is maintained in the event of an SBO for the specified duration. The capability for coping with an SBO of specified duration shall be determined by an appropriate coping analysis.

The term "Station Blackout" as defined in 10 CFR 50.2 (Reference 8.2-13) means the complete loss of ac electric power to the essential and non essential switchgear buses in a nuclear power plant (i.e., the loss of offsite electric power system concurrent with a turbine trip and the unavailability of the onsite emergency ac power system). An SBO does not include the loss of available ac power to buses fed by the station batteries through inverters or by AAC sources, nor does it assume a concurrent single failure or DBA.

In accordance with 10 CFR 50.63(c)(2) (Reference 8.2-5), AAC power sources as defined in 10 CFR 50.2 (Reference 8.2-13) constitute acceptable capability to withstand an SBO provided an analysis is performed which demonstrates that the plant has that capability from the onset of an SBO until the AAC and required shutdown equipment are started and lined up to operate. AAC source(s) serving a multiple unit site where emergency ac sources are not shared between units must have, as a minimum, the capacity and capability for coping with an SBO in any of the units. If the AAC meets the above requirements and can be demonstrated by testing that power is available to the shutdown buses within 10 minutes from the onset of an SBO, then no coping analysis is required.

The strategies and design enhancements of the US-APWR to incorporate lessons learned from the Great Tohoku Earthquake and the Tsunami which hit the Fukushima Dai-ichi Nuclear Power Station on March 11, 2011, and the conformance with the recommendations issued after the accident by the US NRC, are summarized in the technical report “US-APWR Evaluation and Design Enhancement to Incorporate Lessons Learned from TEPCO's Fukushima Dai-ichi Nuclear Power Station Accident” (Reference 8.4-4). AAC power sources are designed to be operational after a safe shutdown earthquake (SSE).

8.4.1.2 Design Description

The offsite electrical connections to the plant onsite safety and non safety electrical systems and the operation during normal and emergency conditions are described in detail in Section 8.2.

Offsite ac electric power is provided to the onsite ac power system from the grid and other generating stations by at least two physically independent transmission lines. One of these two transmission tie lines connects to the high voltage side of the MT, and the other connects to the high voltage side of the RATs. The MG is connected to the low voltage side of the MT and the high voltage side of the UATs. The normal offsite ac power source for non-Class 1E MV buses N1, N2, N3, N4, N5, N6, P1 and P2 is through the UATs and the alternate ac power source is through the RATs. The normal power ac source for the Class 1E MV buses A, B, C and D is through the RATs and the alternate ac power source is through the UATs. Both normal and alternate ac power sources have the capability to serve the total plant auxiliary loads during all modes of plant operation including PA conditions. If power is not available through the normal offsite ac power source, power supply to the onsite ac electric system is transferred automatically to the alternate offsite ac power source.

The onsite Class 1E electrical distribution system connections and operation during normal and emergency conditions are described in detail in Section 8.3. The onsite Class 1E electrical distribution system consists of four physically separate and electrically isolated trains A, B, C, and D. The availability of any two trains is adequate to meet the electrical load requirement during LOOP, and LOOP and LOCA occurring simultaneously. Each train consists of 6.9 kV, 480 V, and 120 V ac, and 125 V dc distribution systems. Each train is backed up by an independent Class 1E GTG connected to the Class 1E 6.9 kV bus. The required SBO coping duration for US-APWR is based on the target reliability of 0.95 per demand for each Class 1E GTG consistent with the guidelines in Section C.1.1 of RG 1.155 (Reference 8.3.1-21).

The offsite and onsite power system design fully conforms to the requirements of 10 CFR 50, Appendix A, GDC 17 and 18 (Reference 8.1-3).

During an SBO, all offsite ac sources and the onsite Class 1E GTGs are assumed to be inoperable. Since provision of AAC sources constitute an acceptable capability to withstand an SBO in accordance with 10 CFR 50.63(c)(2) (Reference 8.2-5), two non-Class 1E GTGs are provided as AAC sources. In accordance with 10 CFR 50.63(c)(2) (Reference 8.2-5), analysis is required to demonstrate that the plant has the capability to cope with an SBO from the onset of the SBO until the AAC and the required shutdown equipment are started and lined up to operate. However, in accordance with 10 CFR 50.63(c)(2) (Reference 8.2-5), coping analysis is not required if the AAC source can be demonstrated to be available to power shutdown buses within 10 minutes of the onset of the SBO. In the US-APWR design, power to the shutdown buses can be restored from the AAC sources within 60 minutes and, hence, coping analysis for a duration of 60 minutes is performed. Availability of power from the AAC GTG to one Class 1E 6.9kV bus within 60 minutes is verified by actual field testing. A detailed coping analysis is included in Subsection 8.4.2.1.2.

8.4.1.3 Alternate AC Power Sources

AAC power sources and their connections to the onsite and offsite ac power systems meet the requirements of RG 1.155 (Reference 8.3.1-21).

Two full capacity 4600 kW, 6.9 kV non-Class 1E GTGs (A and B) are provided as AAC sources and any one of these two GTGs can meet the SBO load requirements shown in Table 8.3.1-6 for the time required to bring and maintain the plant in a safe shutdown condition. Two AAC GTGs are provided for operational flexibility and enhanced reliability, even though the provision of one AAC GTG is adequate to meet the requirements of RG 1.155 (Reference 8.3.1-21). RG 1.155 Appendix B (Reference 8.3.1-21) does not require a single failure criterion to be applicable to the AAC power source. Hence, the provision of two 100% capacity AAC sources will provide greater US-APWR reliability for coping with an SBO event than what is intended by RG 1.155 (Reference 8.3.1-21). The AAC power sources reach set voltage and frequency within 100 seconds from receiving the starting signal. Controls exist in the MCR to start, stop and synchronize the AAC power sources.

To minimize the potential for common mode failures with the Class 1E GTGs, GTGs of different manufacturer from Class 1E GTGs are provided as AAC sources. The auxiliary and support systems for the AAC GTGs are independent and separate from the Class 1E GTGs to minimize the potential for common mode failures. Completely separate and independent fuel supply systems and onsite fuel storage tanks are provided for the Class 1E GTGs and for the non-Class 1E AAC GTGs.

The A-AAC GTG and B-AAC GTG are located in separate rooms in the PS/B. A-AAC GTG is connected to the non-Class 1E 6.9 kV permanent bus P1 through a selector circuit A. Similarly, B-AAC GTG is connected to the non-Class 1E 6.9 kV permanent bus P2 through a selector circuit B. The selector circuit consists of one circuit breaker connected to the AAC source and three circuit breakers. The circuit breakers in the selector circuit A are connected to the 6.9 kV buses P1, A and B (or P2, C and D for selector circuit B) through tie lines, as shown in Figure 8.3.1-1.

The A-AAC GTG and B-AAC GTG are connected to the circuit breakers in selector circuits A and B, respectively. The selector circuits A and B are located in the PS/B. The non-Class 1E 6.9 kV and 480 V permanent power supply systems P11, P12, P21 and P22 are located in the T/B electrical room. These AAC GTG circuit breakers in the selector circuits A and B are normally open and the AAC power sources are not normally connected directly to the plant offsite or onsite power system. The Class 1E circuit breakers in the Class 1E MV switchgears are connected to the circuit breakers (non-Class 1E) in the selector circuits A and B as shown in Figure 8.3.1-1. The non-Class 1E circuit breakers in the selector circuits A and B, and the Class 1E incoming circuit breakers in the Class 1E MV switchgear from the AAC GTG are normally open and do not have any automatic closing function. They perform the isolation between the Class 1E and the non-Class 1E system. This meets RG 1.155, Appendix B (Reference

8.3.1-21) requirements for isolation between AAC sources and the onsite and offsite power systems.

The adoption of different manufacturers and diverse starting mechanisms between the AAC power sources and the emergency ac power sources, the location of AAC sources in separate rooms, the independent auxiliaries, and the interconnections to the offsite and onsite emergency ac power systems ensure that no single point of vulnerability exists. Therefore, a weather-related event or a single failure could not disable all the onsite emergency ac sources and offsite ac power supplies simultaneously along with all the AAC sources.

The AAC sources can be started and connected manually to the onsite Class 1E MV buses within 60 minutes during SBO conditions.

The restoration of power from any one of the AAC sources to any one of the onsite Class 1E MV buses (A-AAC GTG to the Class 1E 6.9kV buses A or B, or B-AAC GTG to the 6.9kV Class 1E buses C or D) is adequate to cope with the SBO condition. The sequence of switching operations for restoring power to the Class 1E 6.9kV buses A or B from the A-AAC GTG during an SBO is described in the following procedure. The sequence of switching operations for restoring power from the B-AAC GTG to the Class 1E 6.9kV buses C or D during an SBO is similar:

1. The A-AAC GTG is started automatically by the undervoltage signal on the 6.9 kV permanent bus P1 due to LOOP.

2. The incoming breakers from the offsite power supply sources to the 6.9 kV permanent bus P1 are tripped and locked out by the undervoltage signal on bus P1.

3. The circuit breaker in the selector circuit connecting to 6.9 kV permanent bus P1 and the circuit breaker on the non-Class 1E 6.9 kV permanent bus P1 are normally closed.

4. The circuit breaker A in the selector circuit A for the A-AAC GTG is closed automatically after the A-AAC GTG reaches the set voltage and frequency and the power supply from the A-AAC GTG is restored to the 6.9 kV permanent bus P1 automatically. The loads on the non-Class 1E 6.9 kV and the 480 V permanent buses P1 are started automatically by the LOOP sequencer.

5. The circuit breakers in the selector circuit A and the incoming circuit breakers from AAC in the Class 1E 6.9 kV switchgear are normally open. Hence, power from AAC source is not restored automatically to the onsite Class 1E 6.9 kV buses A or B.

6. Most of the ac loads on the Class 1E 6.9kV buses A and B are tripped by undervoltage signal except the feeders to the 480 V load centers, battery chargers, emergency lighting etc. Before restoring the power supply to the Class 1E buses from the A-AAC GTG, the loads supplied from the non-Class 1E permanent bus P1, are tripped manually.

7. Power is restored to one of the Class 1E 6.9 kV buses A or B from A-AAC GTG by manually closing the associated circuit breaker in selector circuit A and the Class 1E incoming circuit breaker in the 6.9 kV Class 1E bus A or B from A-AAC GTG.

8. After restoration of power supply to the 6.9 kV Class 1E bus A or B from the A-AAC GTG, the required loads on the 6.9 kV and 480 V Class 1E buses A or B, as shown in Table 8.3.1-6, are started manually.

The AAC GTGs have enough fuel capacity to supply power to the required SBO loads for 8 hours.

Power sources which achieve and maintain cold shutdown become available when the two AAC GTGs start and the second AAC GTG is connected to the other Class 1E bus in a manner that is similar to the way the first AAC GTG is connected.

8.4.1.4 Recovery from SBO

Within the required coping duration of 8 hours, power supply to the Class 1E buses would be restored either from the onsite Class 1E GTGs or from the offsite ac power sources as follows.

A. Recovery from SBO with available offsite source

1. The output of AAC GTG is adjusted to synchronize with the offsite power.

2. If the offsite ac source from RAT is available, the incoming breaker from RAT to the 6.9kV permanent bus is closed, after synchronizing the AAC GTG with the offsite ac source.

3. If the offsite ac source from UAT is available, the incoming breaker from UAT to the 6.9kV permanent bus is closed, after synchronizing the AAC GTG with the offsite ac source.

4. The AAC GTG governor is adjusted to unload the AAC GTG and the load is transferred to the offsite ac source.

5. When there is no load on AAC GTG, the circuit breaker in the Class 1E bus and the circuit breaker in the selector circuit connected to the AAC GTG are tripped to isolate the Class 1E bus from the AAC GTG.

B. Recovery from SBO with the Class 1E GTG

1. The output of AAC GTG is adjusted to synchronize with Class 1E GTG.

2. After synchronizing the AAC GTG with the Class 1E GTG, circuit breaker from the Class 1E GTG is closed.

3. The AAC GTG governor is adjusted to unload the AAC GTG and the load is transferred to the Class 1E GTG.

4. When there is no load on AAC GTG, the circuit breaker in the Class 1E bus and the circuit breaker in the selector circuit connected to the AAC GTG are tripped to isolate the Class 1E bus from the AAC GTG.

8.4.2 Analysis

8.4.2.1 Compliance with 10 CFR Part 50.63

10 CFR 50.63 (Reference 8.2-5) requires that each light-water-reactor-cooled power plant licensed to operate must be able to withstand an SBO for a specific duration and recover from an SBO.

The SBO rule, in accordance with 10 CFR 50.63 (Reference 8.2-5), requires each plant to specify a proposed SBO coping duration to be used in determining compliance based onsite and plant specific factors that contribute to the likelihood and duration of an SBO. The expected maximum coping duration for the US-APWR is determined based on the guidance provided in RG 1.155 (Reference 8.3.1-21).

8.4.2.1.1 Station Blackout Coping Duration

The specific SBO duration is based on the redundancy of the onsite emergency ac power sources, the reliability of the onsite emergency ac power sources, the expected frequency of LOOP and the probable time needed to restore offsite power. The coping duration is based on the following design characteristics using RG 1.155, Section C.3.1 (Reference 8.3.1-21) methodology:

1. The transmission system, plant high voltage switchyard, grid system, and interconnections to other grid systems and generating stations are site-specific and not part of the design control document (DCD). There would be a minimum of two physically independent transmission lines between the offsite grid systems and the plant high voltage switchyard and transmission tie lines from the plant high voltage switchyard to the onsite transformer yard. These are discussed in Section 8.2. The offsite power system design fully conforms to 10 CFR 50, Appendix A, GDC 17 and 18 (Reference 8.1-3). Since the offsite power design characteristics are site-specific, the characteristic group "P3" in accordance with Table 4 of RG 1.155 (Reference 8.3.1-21) that results in the longest SBO coping duration is considered for conservatism.

2. The onsite emergency ac power supply system design provides four redundant and independent emergency Class 1E GTGs and any two of the four emergency Class 1E GTGs are adequate to operate the ac powered decay heat removal systems. Therefore, emergency power configuration group is classified as "B" in accordance with Table 3 of RG 1.155 (Reference 8.3.1-21).

3. Emergency Class 1E GTG minimum targeted reliability determined in accordance with Section C.1.1 of RG 1.155 (Reference 8.3.1-21) is 0.95 per demand for each GTG.

Based on the above, the acceptable SBO coping duration is 8 hours in accordance with Table 2 of RG 1.155 (Reference 8.3.1-21).

8.4.2.1.2 Station Blackout Coping Analysis

The SBO rule in accordance with 10 CFR 50.63 (Reference 8.2-5) states that no coping analysis is required if the AAC sources can be demonstrated by test to be available to power the shutdown buses within 10 minutes of the onset of an SBO.

Two GTGs of a different manufacturer from the Class 1E GTGs are provided as AAC sources. These AAC GTGs are independent from the Class 1E GTGs and do not share any common auxiliaries or support systems. The AAC GTGs are not normally connected to the plant offsite or onsite power systems. The AAC GTGs are electrically isolated from the emergency Class 1E power supply systems by a non-Class 1E circuit breaker and a Class 1E circuit breaker. The circuit breaker and the Class 1E circuit breaker connecting the AAC GTG to the Class 1E buses are normally open, and would be manually closed during an SBO to restore the power supply to one of the Class 1E 6.9 kV buses A or B, or C or D. The AAC GTGs are automatically started by the undervoltage signal on the 6.9kV permanent buses P1 or P2 and connected to the respective 6.9kV permanent bus P1 or P2 during LOOP. The AAC GTGs can also be manually started and connected to the Class 1E emergency buses. The AAC GTGs start and reach the rated frequency and voltage and are ready to be loaded within 100 seconds. Each AAC source is capable of providing adequate power to the emergency shutdown buses. The power supply from the AAC GTG to one of the Class 1E buses can be restored within 60 minutes. Availability of power from the AAC GTG to one Class 1E 6.9kV bus within 60 minutes is verified by actual field testing. Since the power supply from the AAC GTG to the Class 1E buses cannot be restored within 10 minutes, the following coping analysis is performed for the US-APWR in accordance with the requirements of Section C.3.2 of RG 1.155 (Reference 8.3.1-21):

1. After SBO occurs, all ac power sources including all Class 1E GTGs, are lost, except for ac power from the UPS. Power from the AAC GTG will be restored to the required Class 1E power system within 60 minutes. During the 60 minutes, no pumps and fans connected to the Class 1E 6.9kV and 480V ac buses can be operated.

2. With the plant be in above condition, the systems can be kept in safe condition as described below:

   (1) RCP seal

   RCP seal can keep its integrity for at least one hour without water cooling as described in Chapter 5.4.1.4.9. There is no LOCA considered in this condition.

   (2) Integrity of electrical cabinets

   Until AAC GTG restores power to the Class 1E power system within one hour after SBO occurs, Class 1E electrical room HVAC system cannot be operated. However, all Class 1E electrical cabinets and I&C cabinets are rated to keep their integrity up to 50°C temperature. The temperature of

Class 1E electrical room and I&C room will not reach 50°C within one hour even without HVAC.

(3) Integrity of T/D EFW pump

Until AAC GTG restores power to the Class 1E power system within one hour after SBO occurs, turbine driven (T/D) emergency feedwater (EFW) pump room HVAC system cannot be operated. However, T/D EFW system mechanical and electrical equipment, including EFW turbine control system components, are rated to keep their integrity up to 175°F temperature. The temperature of T/D EFW pump room will not reach 175°F within one hour even without HVAC.

3. After AAC GTG has restored power to the Class 1E power system, the following operations will be performed and the plant will be in a safe shutdown condition for the long term:

Function	Action
Reactivity control	Supplying boric acid tank (BAT) water by using charging pump
reactor coolant system (RCS) make up	Supplying water of refueling water auxiliary tank by using charging pump
RCS pressure control	Pressurizing by using pressurizer backup heater and depressurizing by using safety depressurization valve (SDV)
Decay heat removal	Supplying EFW pit water by using T/D EFW pump and Steam relieved by using Main Steam Relief Valve
Cooling of RCP seal	RCP seal injection by using charging pump (Water source is refueling water auxiliary Tank)
Supporting system	I&C, cooling system, HVAC

The plant can be kept in the safe shutdown condition by the above operations performed only on one Class 1E train.

8.4.2.2 Conformance with Regulatory Guidance

The offsite and onsite emergency power supply systems meet 10 CFR 50, Appendix A, GDC 17 and 18 (Reference 8.1-3).

RG 1.155, “Station Blackout,” (Reference 8.3.1-21) provides a means acceptable to the NRC staff for meeting the requirements of 10 CFR 50.63 (Reference 8.2-5).

NUMARC-87-00 (Reference 8.4-1) also provides guidance acceptable to the staff for meeting these requirements. RG 1.155 (Reference 8.3.1-21) takes precedence when noted in Table 1 of RG 1.155 (Reference 8.3.1-21). The AAC power sources are designed in accordance with RG 1.155 (Reference 8.3.1-21) and manufacturer's standards. NUMARC 87-00 (Reference 8.4-1) is used for clarification, as permitted by RG 1.155. The PSFSV ventilation system is designed in accordance with manufacturer's standards.

The non-Class 1E AAC power supplies and the connections to the onsite emergency Class 1E power supply system meet all the requirements of RG 1.155 (Reference 8.3.1-21). The AAC power sources meet the recommendations listed under Section C.3.3.5 of RG 1.155 as discussed in the following paragraphs.

Two AAC GTGs, which are independent and of different manufacturer from the Class 1E ac power sources, are provided as AAC sources to minimize common mode failures. This meets the criterion of having power sources that are independent and diverse from the normal Class 1E ac power sources in accordance with Section C.3.2.5 of RG 1.155 (Reference 8.3.1-21).

The AAC GTGs are not normally connected to the offsite or onsite emergency ac power supply systems. The AAC GTGs are connected to the non-Class 1E 6.9 kV permanent buses, P1 and P2 only during LOOP or online test of AAC GTG conditions. The AAC GTGs and their associated non-Class 1E selector circuits A and B are located in separate rooms. The AAC GTGs and the onsite Class 1E ac power system are electrically isolated by a circuit breaker (non-Class 1E) and a circuit breaker (Class 1E) in series. The auxiliaries and support systems for the AAC GTGs are separate and are not shared with the onsite Class 1E ac systems. Therefore, no single point vulnerability exists whereby a weather-related event or single active failure could disable any portion of the blacked-out unit's onsite Class 1E power sources or the offsite power sources and simultaneously fail the AAC GTGs. This meets the criteria 1 and 2 of Section C.3.3.5 of RG 1.155 (Reference 8.3.1-21).

The AAC GTGs are automatically started by the undervoltage signal on the 6.9 kV permanent buses, P1 or P2, and are automatically connected to their respective permanent buses within 100 seconds. The AAC GTGs can be connected manually to the onsite Class 1E buses by closing the non-Class 1E circuit breaker in the selector circuit and the Class 1E incoming circuit breaker in the Class 1E 6.9 kV switchgear as described in Subsection 8.4.1.3. Power supply to at least one of the onsite Class 1E ac train can be restored from the AAC sources within 60 minutes. The availability of power supply to one of the four Class 1E trains is adequate for coping with an SBO event. This meets the requirements of Criterion 3 of Section C.3.3.5 of RG 1.155 (Reference 8.3.1-21).

Each AAC GTG has sufficient capacity to operate the systems necessary for coping with an SBO event for the time required to bring and maintain the plant in safe shutdown condition. Two AAC GTGs are provided even though the provision of only one is adequate to meet the regulatory requirements. This meets the contingency of one AAC GTG not available. Single failure for the AAC GTGs need not be considered in accordance with Appendix B, RG 1.155 (Reference 8.3.1-21). Each AAC GTG has adequate fuel to operate the systems required for coping with an SBO for 8 hours. Therefore, the AAC GTGs meet Criterion 4 of Section C.3.3.5, RG 1.155 (Reference 8.3.1-21).

A 25 consecutive start preoperational test, without loading, will be performed for each AAC GTG.

The AAC power system will be inspected and tested periodically based on manufacturer's recommendations and Reg 1.155 to demonstrate operability and reliability. The surveillance test interval does not exceed 3 months (Quarterly). During the quarterly test the AAC is started and brought to operating conditions. Additionally, during every refueling outage, the AAC generator is tested by performing a timed start and rated load capacity test. Following preoperational testing, the AAC power system will be maintained to meet or exceed 95% reliability as determined in accordance with NSAC-108 (Reference 8.4-2) or equivalent methodology to meet Criterion 5 of Section C.3.3.5, RG 1.155 (Reference 8.3.1-21). Testing and maintenance of the AAC is evaluated under the reliability assurance program and the maintenance rule program.

Procedures to cope with SBO are addressed in Section 13.5 and the training is addressed in Section 13.2. These include all operator actions necessary to cope with SBO for at least the duration in accordance with Subsection 8.4.2.1.1 and to restore normal long-term core cooling/decay heat removal once ac power is restored. This meets the requirement of Regulatory Position C.3.4 of RG 1.155.

The quality assurance of AAC GTG is controlled in accordance with DCD Chapter 17 and related topical report PQD-HD-19005 Revision 5 (Reference 8.4-3). This meets the requirements of Regulatory Position C.3.5 of RG 1.155.

8.4.3 Combined License Information

No additional information is required to be provided by a COL Applicant in connection with this section.

8.4.4 References

8.4-1 Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors, NUMARC 87-00, Revision. 1, August 1991.

8.4-2 Reliability of Emergency Diesel Generators at U.S Nuclear Power Plants, NSAC-108, September 1986.

8.4-3 Quality Assurance Program (QAP) Description For Design Certification of the US-APWR, PQD-HD-19005 Revision 5, May 2013.

8.4-4 US-APWR Evaluation and Design Enhancement to Incorporate Lessons Learned from TEPCO's Fukushima Dai-ichi Nuclear Power Station Accident, MUAP-13002, Revision 0, March 2013.