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MFN 07-165

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Subject: **Response to RAI 8.3-52 Supplement 1, and Submittal of Editorial Clarifications Related to ESBWR Design Certification Application – DCD Section 8 – Electrical Power**

Enclosure 1 contains GE's response to the subject NRC RAI 8.3-52 transmitted via the Reference 1 letter.

Also attached in Enclosure 2 is a markup copy of pages from DCD Chapter 8 showing non-technical editorial clarifications and corrections, (i.e., technical description clarifications, figure clarifications, and updates to section references) as discussed in our telecom conversation with NRC on April 09, 2007.

The marked up pages attached in Enclosure 2 will be incorporated in the DCD Revision 4 when it is issued.

If you have any questions or require additional information, please contact me.

Sincerely,

Kathy Sedney for

James C. Kinsey
Project Manager, ESBWR Licensing

D068

Reference:

1. Email from I. Berrios (NRC) to D. Lewis, *Sup RAO Ch 8*, dated May 4, 2007
2. MFN 07-143, Letter from David Hinds to U.S. Nuclear Regulatory Commission, *Summary Report - RAI Resolutions Incorporated in ESBWR Design Control Document, Revision 3, and RAI Response Schedule*, dated March 12, 2007
3. MFN 07-105, Letter from U.S. Nuclear Regulatory Commission to David Hinds, *Request for Additional Information Letter No. 92 Related to ESBWR Design Certification Application*, dated January 31, 2007

Enclosure:

1. MFN 07-165, RAI Response to RAI 8.3-52 Supplement 1
2. DCD Section 8 Editorial Markups

cc: AE Cubbage USNRC (with enclosures)
RE Brown GE/Wilmington (with enclosures)
GB Stramback GE/San Jose (with enclosures)
eDRF 0000-0068-0672

MFN 07-165

Enclosure 1

RAI Response to RAI 8.3-52 Supplement 1

For historical purposes, the original text of RAI 8.3-52 and the GE response is included.

<u>RAI 8.3-52:</u> (Reference MFN 07-143, Enclosure 1)

Address battery load profile. DCD Tier 2, Table 8.3-6 should identify an ESBWR common design load profile rather than defer the information as a COL item.

<u>Original GE Response:</u>

Deleted T8.3-6, "Class 1E Battery Loading Profile." This information is covered in ITAAC 2.13.3-1, 3a.

Also, deleted T8.3-7, "Amp. Hour Load Table for 72 Hour Battery Rate." This information is covered in ITAAC 2.13.3-1, 3a.

<u>RAI 8.3-52, Supplement 01</u>

Provide loading profile for safety-related DC power systems based on each of safety-related UPS buses, Bus Nos. 11, 12, 21, 22, 31, 32, 41, and 42.

<u>GE Response:</u>

As clarification, RAI 8.3-52 was responded to in the change list that was provided with DCD Chapter 8 Revision 3 and later summarized in MFN 07-143.

In response to the above RAI 8.3-52 S01 received Friday, May 4, 2007, GE provides the following: The loading profile will not be provided until the DCIS loads are established. The DRAFT safety-related DCIS loads are currently scheduled for approximately Sept. 2008 with confirmed loads not being known until 12/2011 to 6/2012, based on having actual procured vendor loads for the load profile. The Subsection **8.3.2.1.1 Safety-Related Batteries**, states that "the two batteries in each division are rated to exceed 72 hours and are **<u>sized for the DC load in accordance with IEEE Standard 485 (Reference 8.3-2) with an expected 20-year service life</u>**." The same subsection, under **Inspection, Maintenance, and Testing** states that "battery capacity tests are conducted in accordance with IEEE 1188 (Reference 8.3-8). These tests ensure that the battery has the capacity to meet safety-related load demands." The final load profile will have an analyses performed and tested in accordance with ITAAC Table 2.13.3-1, 3a. & 3b. Acceptance Criteria.

3a). Analyses reports of the as-built batteries exist and conclude that two sets of safety-related batteries in each division have the capacity, as determined by the vendor performance specification, to supply its rated constant current, for a minimum of 72 hours without recharging.

3b). Test report(s) conclude that the capacity of each as-built safety-related battery equals or exceeds the analyzed battery design duty cycle capacity.

The selected batteries are capable of being sized to meet the above stated criteria without expansion of the current rooms designated for each division's batteries. A preliminary battery size has been selected to meet the estimated maximum design load profile with the ability to increase the battery size by 50% of the estimated size if necessary.

DCD Impact:

No additional DCD Tier 2 changes will be made in response to this RAI.

MFN 07-165

Enclosure 2

DCD Section 8 Editorial Markups

8. ELECTRIC POWER

8.1 INTRODUCTION

8.1.1 General

Description of the ESBWR Electric Power Distribution System provided herein applies to the "~~reference~~ standard plant design".

Power is supplied to the plant from two independent offsite power sources, the "Normal Preferred" power source and the "Alternate Preferred" power source. The loss of both preferred sources may be referred to as a Loss of Preferred Power (LOPP) or a Loss of Offsite Power (LOOP). The terms may be used interchangeably. These power source connections are designed to provide reliable power sources for the plant auxiliary loads, such that any single active failure can affect only one power source and cannot propagate to the alternate power source.

The ~~on-site~~onsite AC power system consists of safety-related and nonsafety-related power systems. The two offsite power systems provide the normal preferred and alternate preferred AC power to safety-related and nonsafety-related loads. In the event of total loss of offsite power sources and loss of main generator island mode operation, two onsite independent nonsafety-related standby diesel generators are provided to power the plant~~'s~~ investment protection (PIP) nonsafety-related loads and safety-related loads through battery chargers. There are four independent safety-related DC divisions to provide power for the safety-related loads.

Onsite safety-related and nonsafety-related DC systems supply all the DC power requirements of the plant.

8.1.2 Utility Power Grid and Offsite Power System Descriptions

8.1.2.1 Utility Power Grid Description

The utility power grid description is provided in Subsection 8.2.1.

8.1.2.2 Offsite Power System Description

The offsite power system consists of the set of electrical circuits and associated equipment that are used to interconnect the offsite transmission system with the plant main generator and the onsite electrical power distribution system, as indicated on the one-line diagram, Figure 8.1-1.

The system includes the ~~plant~~ switchyard and the high voltage tie lines to the main generator circuit breaker, the high-side motor operated disconnects (MODs) of the unit auxiliary transformers (UATs), and the high-side MODs of the reserve auxiliary transformers (RATs).

The offsite power system begins at the terminals on the transmission system side of the circuit breakers that connect the ~~switching stations~~switchyard to the offsite transmission systems. It ends at the connection to the input terminals of the MODs of the UATs, RATs, and main generator circuit breaker.

Power is supplied to the plant from the switchyard connected to the transmission grid offsite power sources as follows:

- "Normal Preferred" source through the UATs; and

- "Alternate Preferred" source through the RATs.

During plant startup, emergency shutdown, or during plant outages, the offsite power system serves to supply power from the offsite transmission system to the plant auxiliary and service loads.

During normal operation, the main generator transmits generated power to the offsite transmission system through the main transformers and to the plant auxiliary and service loads through the UATs.

The onsite power distribution system is powered continuously by the normal preferred power source during shutdown and throughout plant startup. When the onsite main generator breaker is tripped, power to the plant continues to be fed from the normal preferred power source to the UATs or directly to the RATs through the alternate preferred power source line.

A detailed description of the offsite power system is provided in Subsection 8.2.1.

8.1.3 Onsite Electric Power System

8.1.3.1 ~~On-site~~Onsite AC Power System

The onsite AC power system includes the main generator, the main transformers, the main generator circuit breaker and high side MODs, the UAT input MODs and circuit breakers, the RAT input MODs, and the unit and reserve auxiliary transformers, as indicated on Figure 8.1-1.

The onsite power system is divided into two power load groups at the 13.8 kV and 6.9 kV level for operational flexibility of the plant nonsafety-related systems. Each UAT feeds half of the 13.8 kV and 6.9 kV power load groups and a RAT backs up each UAT.

The first power load group (13.8 kV) supplies power to nonsafety-related power generation loads required primarily for unit operation.

The second power load group (6.9 kV) supplies power to PIP A and PIP B (nonsafety-related loads), which, on account of their specific functions, are generally required to remain operational at all times or when the unit is shut down. The second power load group also supplies power to the safety-related loads through ~~isolation buses~~Isolation Power Centers.

Both PIP A and PIP B buses have a standby power supply from separate onsite standby diesel generators, in addition to their normal preferred power supply through the UATs, and their alternate preferred power supply from an independent offsite source through the RATs.

The first load group distributes power at 60 Hz and voltage levels of 13.8 kV, 480V, 240/120V and 208/120V.

The second load group distributes power at 60 Hz and voltage levels of 6.9 kV, 480V, 240/120V and 208/120V.

A detailed description of the onsite AC power system is provided in Subsection 8.3.1.

8.1.3.2 Onsite DC Power System

The onsite DC power system includes the plant batteries and battery chargers and their DC loads, including the DC/AC inverters and the inverter loads.

The nonsafety-related 125 VDC power system, Figure 8.1-2, provides power for nonsafety-related loads, communications, lighting and other DC loads. The 250V batteries are provided to supply DC power to the plant Nonsafety-Related Distributed Control and Information System (N-DCIS) and nonsafety-related DC motors. The 125 VDC power and 250 VDC power are normally supplied through nonsafety-related battery chargers from the nonsafety-related PIP buses. In the event that this power supply is lost, power is supplied from the nonsafety-related batteries.

The safety-related 250 VDC power distribution system, Figure 8.1-3, provides four independent and redundant ~~on-site~~onsite sources of power for operation of safety-related DC loads including the Safety-Related Distributed Control and Information System (Q-DCIS) . The safety-related 250 VDC power is normally supplied through the safety-related battery chargers from the Isolation Power Centers, which are powered from the PIP buses. In the event that this power supply is lost, DC power is supplied from the safety-related batteries for 72 hours. The system is physically and electrically separated into four divisions.

A detailed description of the onsite DC power system is provided in Subsection 8.3.2.

8.1.4 Safety-Related Loads

The safety-related loads utilize the four divisions of DC power sources for instrumentation or control power, for systems required for safe shutdown. Multiple divisions of DC power are involved in performing a single safety-related function and ensure that only two divisions of DC power are required for safe shutdown during a ~~DBE~~DBA. The control and instrumentation systems required for safe shutdown are identified in Section 7.4, which indicate the four separate divisions of power to each system required for safe shutdown, as shown in Figure 8.1-4.

8.1.5 Design Basis

8.1.5.1 Offsite Power

The offsite power system is described in Subsection 8.2.1.

Electric power from the utility grid to the offsite power system is provided by transmission lines designed and located to minimize the likelihood of failure while ensuring grid reliability. The transmission system serves the main offsite power circuit (Normal Preferred Power), and the reserve offsite power circuit (Alternate Preferred Power) through the site switchyard.

The switchyard is designed to minimize the likelihood of simultaneous failure to both the normal and alternate preferred power sources from the switchyard to the main generator circuit breaker, UATs, and RATs.

A single tie line connects the plant main generator circuit breaker MOD and UAT MODs to the switchyard and constitutes the plant's normal preferred offsite power circuit.

A second offsite (alternate preferred) power circuit is ~~provided~~connected to the MODs at the high side of the RATs. This power circuit is electrically independent and physically separate from the normal preferred power circuit to minimize the likelihood of simultaneous failure.

The offsite power system is designed to provide a continuous source of power to the onsite power system throughout plant startup, normal operation (including shutdown), and abnormal operations with the exception of station blackout.

8.1.5.2 Onsite Power

8.1.5.2.1 General

The main generator circuit breaker is designed to withstand the maximum RMS and crest currents, and to interrupt the maximum asymmetrical and symmetrical currents determined to be produced by a three phase bolted fault at its location.

Three single-phase main step-up transformers are provided as part of the ~~on-site~~onsite power with an additional installed single phase spare. The installation of the spare transformer permits its connection and energization within 24 hours.

The two UATs are provided to supply power to the plant's auxiliary distribution system. The transformers are equal in size, and each has the capacity required to supply power to their load group of safety-related and nonsafety-related systems under conditions of maximum expected concurrent loads, including all required design margins. UATs supply power to their load group ~~from the normal preferred offsite power circuit or~~ through the main transformer from the main generator during normal plant operation and during island mode operation. When the unit is offline, UATs supply power to their load groups from the normal preferred power supply.

Two RATs serve as backup to the UATs. RATs are provided to supply power to the plant's auxiliary distribution system. The transformers are equal in size, and each has the capacity required to supply power to its load group of safety-related and nonsafety-related systems under conditions of maximum expected concurrent loads, including all required design margins. The RATs supply power to their load groups from the alternate preferred power circuit. The RATs are designed to accept the UAT loads through the auto transfer incoming circuit breakers at the 13.8 kV and 6.9 kV switchgear.

The onsite nonsafety-related power distribution system is divided into two power load groups; each group is fed from separate unit and reserve auxiliary transformers. Redundant loads associated with unit operation are powered from buses of separate power load groups.

Two dedicated buses are provided to feed PIP loads. The dedicated buses have three power supplies:

(1) The normal preferred power supply is provided by a UAT connected to the main generator through the main transformer and to the normal preferred offsite power circuit.

(2) The alternate preferred power supply is provided by a RAT connected to an independent offsite source.

(3) The standby power supply is provided by two independent nonsafety-related standby diesel generators of sufficient capacity such that, in the event of a loss of preferred power, each can supply enough power to achieve cold shutdown.

The safety-related loads are powered by four physically separate and electrically independent divisions. Any two out of four divisions can safely shut down the unit and maintain it in a safe shutdown condition.

Each division is fed by a separate 480 VAC Isolation Power Center, which is powered from a PIP nonsafety-related power supply. The nonsafety-related system ends and the safety-related system begins at the input terminals of the main circuit breaker of the Isolation Power Centers. The input power voltage and frequency is monitored and the input breaker tripped if either voltage or frequency is out of the specified limits for a predetermined time. The powering of the Isolation Power Centers with a nonsafety-related power supply does not jeopardize plant safety, since safety-related batteries ~~will~~ supply the required power during loss of AC power. The Isolation Power Centers are also provided with electrical protection through isolation breakers and transformers as shown on Figure 8.1-1 ~~Sheets 2 and 3~~. The battery chargers and AC Power supplied through rectifiers prevent degradation of the safety-related DC power system by the nonsafety-related AC power system through their output diodes as shown in Figure 8.1-3.

The redundant safety-related electrical divisions (Divisions 1, 2, 3 and 4) are provided with separate onsite DC power supplies, electric buses, distribution cables, controls, relays and other redundant electrical devices. Redundant divisions are physically separate and electrically independent so that in a design basis accident with loss of any two divisions, safe plant shutdown for all operating modes can be accomplished with the two remaining divisions of DC power.

Separation criteria are established for preserving the independence of redundant safety-related systems and providing isolation between safety-related and nonsafety-related equipment.

Raceways are not shared by safety-related and nonsafety-related cables, or safety-related cables of a different division. Separate raceways are provided exclusively for each channel group of the Reactor Protection System solenoid wiring.

Special identification criteria, as discussed in Subsection 8.3.1.3, are applied to safety-related equipment, cabling and raceways.

The safety-related 480 VAC and 120 VAC, and 250 VDC power and control systems conform to Seismic Category I requirements and are housed in Seismic Category I structures~~, with the exception of the four feedwater pump safety-related isolation breakers in the Seismic Category II turbine building, as shown in Figure 8.1-1~~. Seismic Qualification is in accordance with IEEE Standard 344 (Section 3.10).

Safety-related equipment and systems have been designed with the capability for periodic testing in accordance with GDC 18.

8.1.5.2.2 Uninterruptible AC Power Supply

The Uninterruptible AC Power Supply (UPS) is divided into two subsystems, the safety-related UPS and the nonsafety-related UPS.

8.1.5.2.2.1 Safety-Related Uninterruptible AC Power Supply

There is no direct safety-related AC power source required for safety-related loads. The safety-related UPS that support the safety-related logic and control functions during normal, upset, and accident conditions are provided from the four divisions of DC power through DC/AC inverters.

Each safety-related battery charger provides the safety-related AC uninterruptible power through separate and independent safety-related inverters connected to the safety-related DC bus of the same division and backed up by its divisional 480 VAC Isolation Power Center (Figure 8.1-4).

Upon loss of AC power to the Isolation Power Centers, the safety-related UPS is powered by its respective division's safety-related battery, and switching from the AC to DC source is transparent to UPS loads. Provision is made for automatic switching to the alternate bypass supply, 480 VAC to 120 VAC transformer, from its division in case of a failure of the UPS

- Regulatory Guide 1.118, "Periodic Testing of Electric Power and Protection Systems" (see Subsection ~~8.3.4.2~~13.5.2 for Operating and Maintenance Procedures and Chapter 16 for Technical Specifications).
- Regulatory Guide 1.128, "Installation Design and Installation of Large Lead Storage Batteries for Nuclear Power Plants." The ESBWR Valve Regulated Lead Acid (VRLA) batteries ~~will~~ limit the release of hydrogen to less than 1% while battery room temperature is within specified vendor limits during charging evolutions. IEEE 344, IEEE 323, and IEEE 1187 apply to VRLA batteries. IEEE 484 is not applicable for VRLA batteries.
- Regulatory Guide 1.129, "Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Nuclear Power Plants" – The ESBWR design allows for periodic testing, maintenance and replacement of batteries in accordance with IEEE 1188. IEEE 450 is not applicable for VRLA batteries.
- Regulatory Guide 1.153, "Criteria for Power Instrumentation, and Control Portions of Safety Systems."
- Regulatory Guide 1.155, "Station Blackout" – The ESBWR does not require AC power to achieve safe shutdown. Thus, the ESBWR meets the intent of Regulatory Guide 1.155. The Station Blackout evaluation is provided in Section 15.5.
- Regulatory Guide 1.160, "Monitoring of Effectiveness of Maintenance at Nuclear Power Plants" - Maintenance Rule development is addressed in ~~Subsection 8.3.4.3~~Table 1.9-21 and Subsection 13.5.2 for Operating and Maintenance Procedures.
- Regulatory Guide 1.204, "Guidelines for Lightning Protection of Nuclear Power Plants" Refer to Subsection 8A.1.2.

Branch Technical Positions:

- BTP ICSB 4 (PSB), "Requirements on Motor-Operated Valves in the ECCS Accumulator Lines" – This BTP is written for pressurized water reactor (PWR) plants only and is therefore not applicable to the ESBWR.
- BTP ICSB 8 (PSB), "Use of Diesel-Generator Sets for Peaking" – The ESBWR can achieve safe shutdown without AC power, and the diesel-generator sets are not safety-related. Therefore, this BTP is not applicable.
- BTP ICSB 11 (PSB), "Stability of Offsite Power Systems" – See Subsection ~~8.2.4.9~~8.2.2.1.
- BTP ICSB 18 (PSB), "Application of the Single Failure Criterion to Manually-Controlled Electrically-Operated Valves" - There are no safety-related, manually-controlled, electrically operated valves in the ESBWR design. All safety-related valves are automatic and require no manual action for 72 hours. This BTP is not applicable to the ESBWR design.
- BTP ICSB 21, "Supplemental Guidance for Bypass and Inoperable Status Indication for Engineered Safety Features Systems."

- BTP PSB 1, "Adequacy of Station Electric Distribution System Voltages" - Degraded Voltage in the offsite power system does not affect the safety-related systems as all safety-related loads are powered from batteries which are isolated by the battery chargers and rectifiers and diodes from the 480 VAC Isolation Power Centers. The 480 VAC Isolation Power Centers do have degraded voltage protection. See Subsection 8.3.1.1.2.
- BTP PSB 2, "Criteria for Alarms and Indications Associated with Diesel-Generator Unit Bypassed and Inoperable Status" - The ESBWR has no safety-related diesel-generator. The ESBWR diesel generator units are nonsafety-related. Therefore this criterion does not apply.

Other SRP Criteria:

- NUREG/CR 0660, "Enhancement of Onsite Diesel Generator Reliability" – The ESBWR diesel-generator units are not safety-related, nor is AC power needed to achieve safe shutdown; therefore, the NUREG is not directly applicable. However, defense-in-depth principles such as redundancy and diversity are incorporated in the design and integration of ESBWR systems.
- NUREG/CR 0737, "TMI Lessons Learned"
- NUREG-0718, Revision 1, "Licensing Requirements for Pending Applications for Construction Permits and Manufacturing License," relating to TMI Item I.D.3, "Safety System Status Monitoring," regarding the application of Regulatory Guide 1.47.
- TMI Action Item II.E.3.1, "Emergency Power Supply for Pressurizer Heater" – This criteria is applicable only to PWRs and does not apply to the ESBWR.
- TMI Action Item II.G.1, "Emergency Power for Pressurizer Equipment" – This criteria is applicable only to PWRs and does not apply to the ESBWR.

8.1.6 Compliance to Regulatory Requirements and Guidelines

Table 8.1-1 presents a matrix of regulatory requirements and guidelines, in accordance with Table 8-1 of the Standard Review Plan. Note that several criteria pertaining to safety-related diesel-generators and/or (direct) AC power systems are not applicable for the ESBWR, because the ESBWR does not require AC power to achieve safe shutdown or to perform any safety-related function. Therefore, the two diesel-generators are nonsafety-related. However, defense-in-depth principles such as redundancy and diversity are incorporated in the design and integration of ESBWR systems.

8.1.7 COL Unit Specific Information

None.

~~8.1.7~~ 8.1.8 References

8.1-1 Title 10, Code of Federal Regulations, Part 50 (10 CFR 50) Appendix A, "General Design Criteria for Nuclear Power Plants."

Table 8.1-1

Onsite Power System SRP Criteria Applicability Matrix

Applicable Criteria		IEEE Standard	Notes	Offsite Power System	AC (Onsite) Power System	DC (Onsite) Power System
GDC	2		7			X
GDC	4		7			X
GDC	5		1			
GDC	17		7	X	X	X
GDC	18		7	X	X	X
GDC	50				X	X
10 CFR	50.34(f)(2)(v)		6			
10 CFR	50.34(f)(2)(xiii)		2			
10 CFR	50.34(f)(2)(xx)		2			
10 CFR	50.63		7			X
RG	1.6			X	X	X
RG	1.9	387	3			
RG	1.32	308, 1188	7	X		X
RG	1.47		7			X
RG	1.53	379,603	7			X
RG	1.63	242, 317, 741			X	X
RG	1.75	384	7			X
RG	1.81		1			
RG	1.106					
RG	1.118	338	7			X
RG	1.128	485, 344, 323, 1187				X
RG	1.129	1188				X
RG	1.153	603	7			X
RG	1.155 (NUMARC 8700)		7			X
RG	1.160 (NUMARC 93-01)			X	X	X
RG	1.204	665, 666, 1050, C62.23		X	X	
BTP	ICSB 4	279	2			
BTP	ICSB 8	308	3		-	
BTP	ICSB 11			X		
BTP	ICSB 18					
BTP	ICSB 21		7			X
BTP	PSB 1				X	
BTP	PSB 2		3			

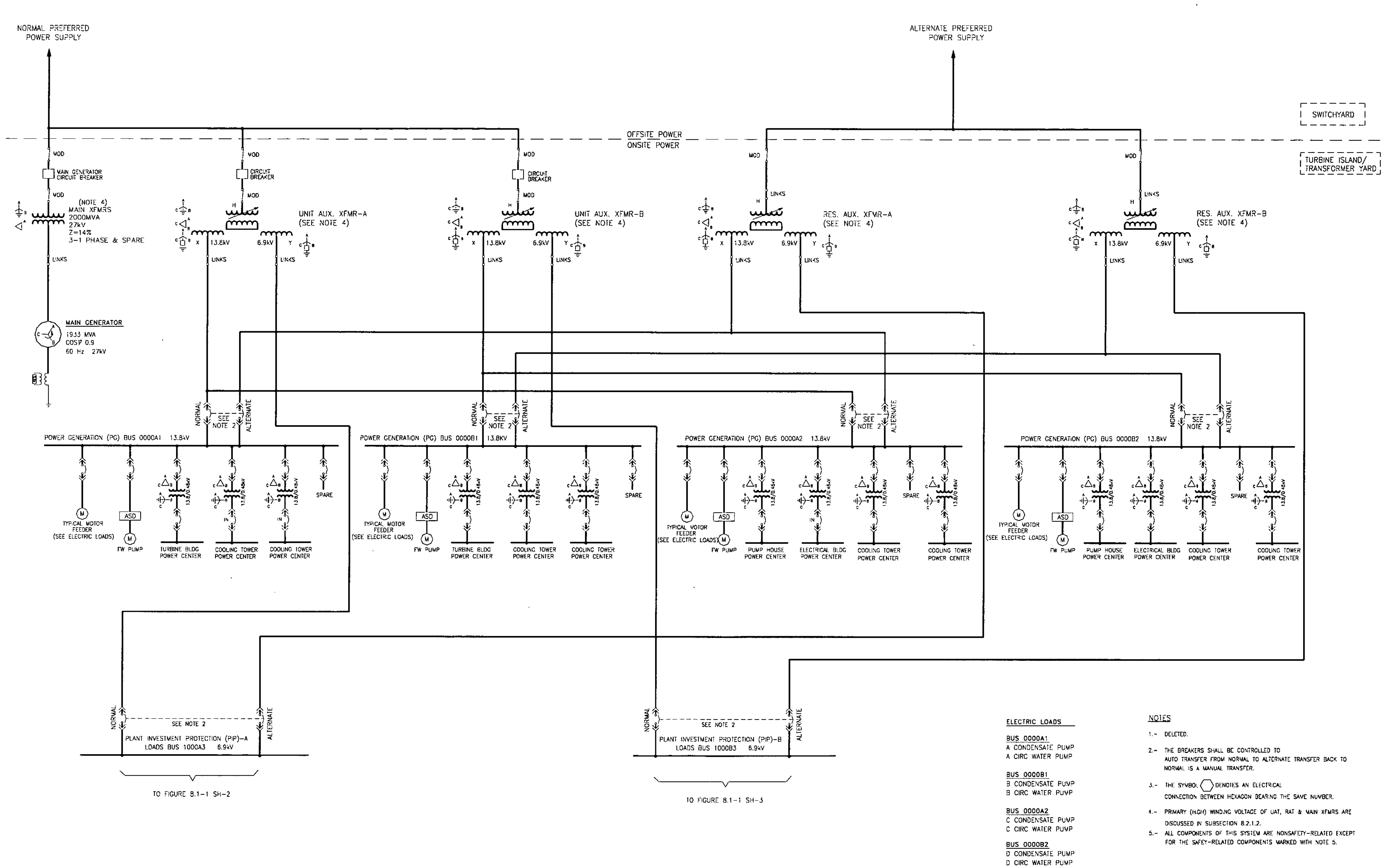

Figure 8.1-1. Electrical Power Distribution System

Sh 1 of 3

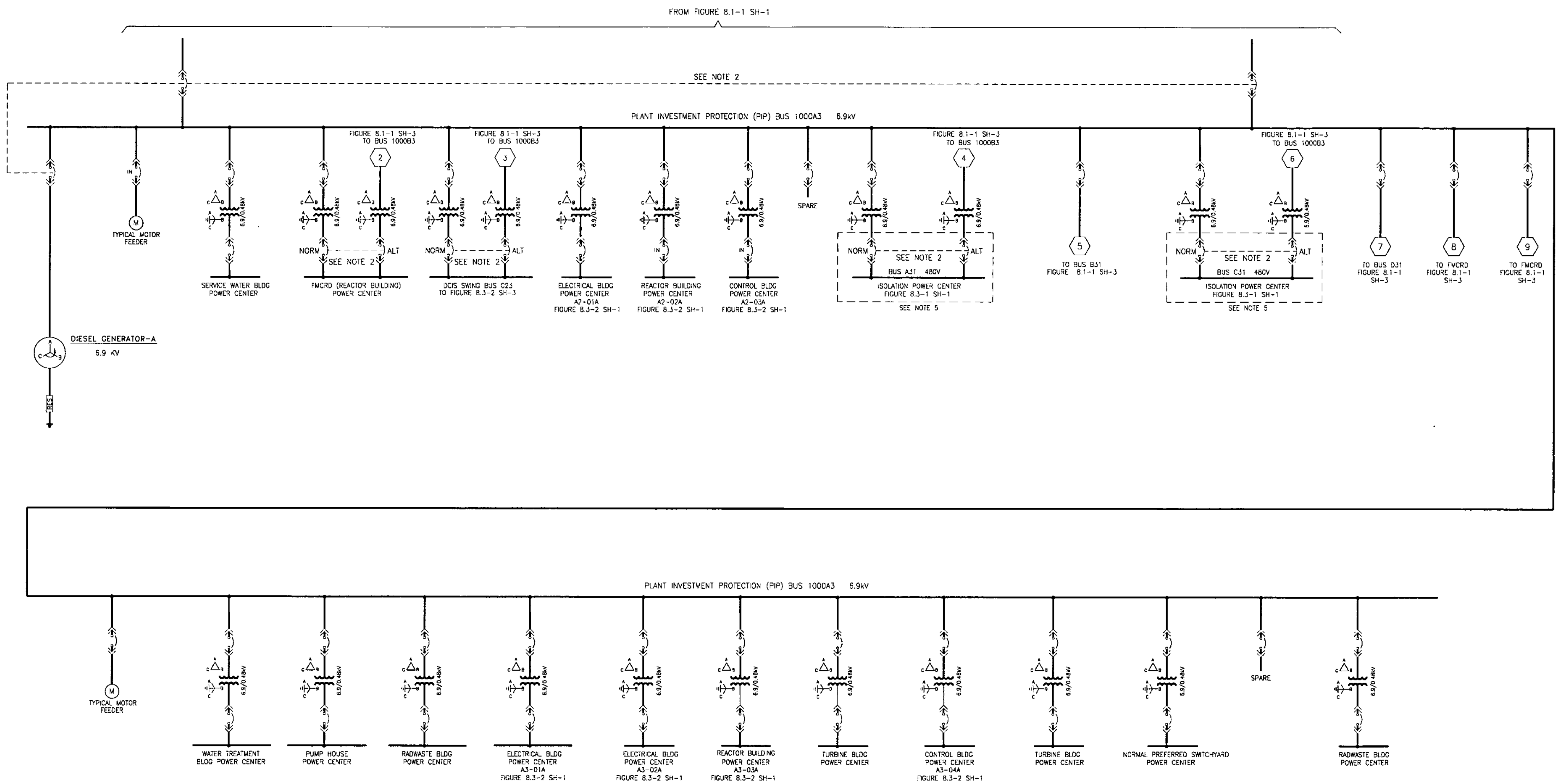

Figure 8.1-1. Electrical Power Distribution System
Sh 2 of 3

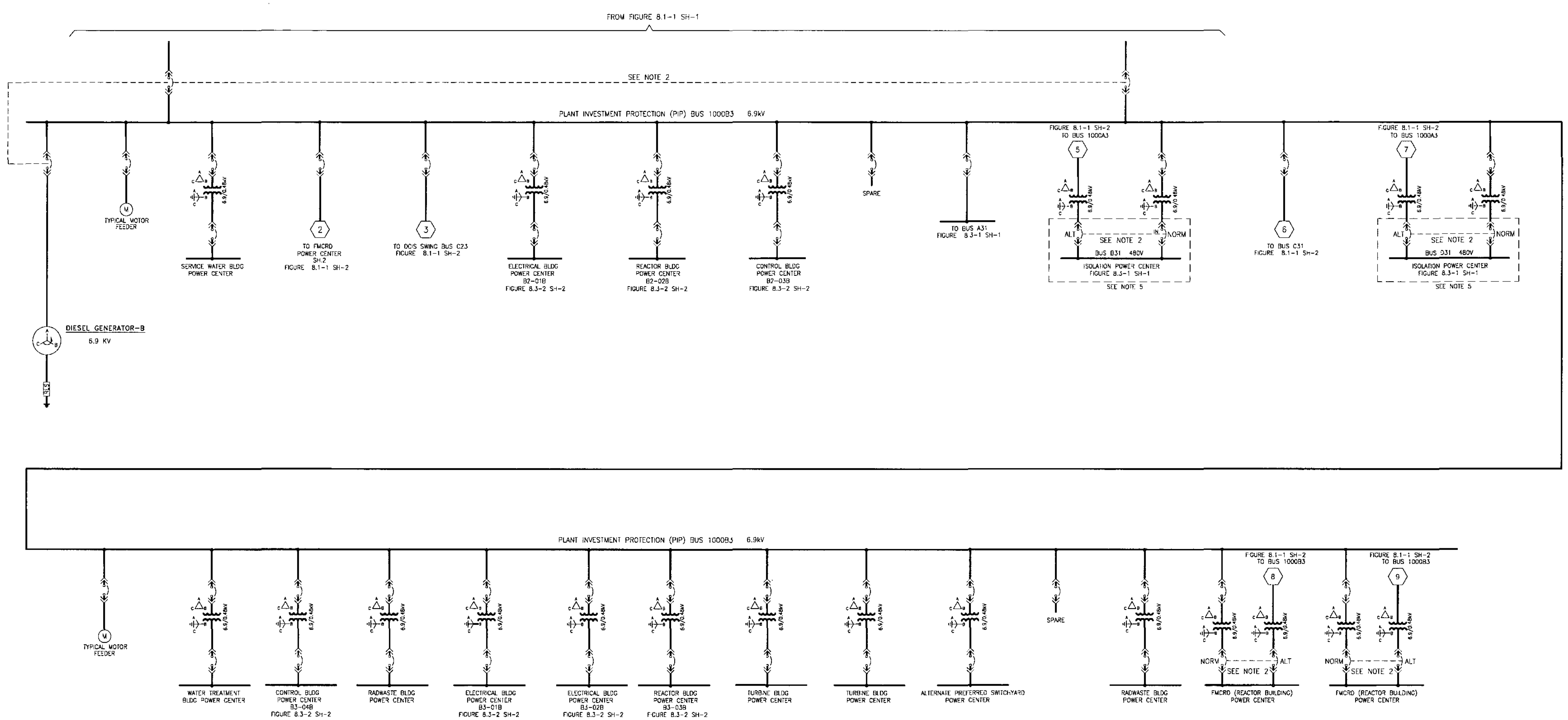

Figure 8.1-1. Electrical Power Distribution System
Sh 3 of 3

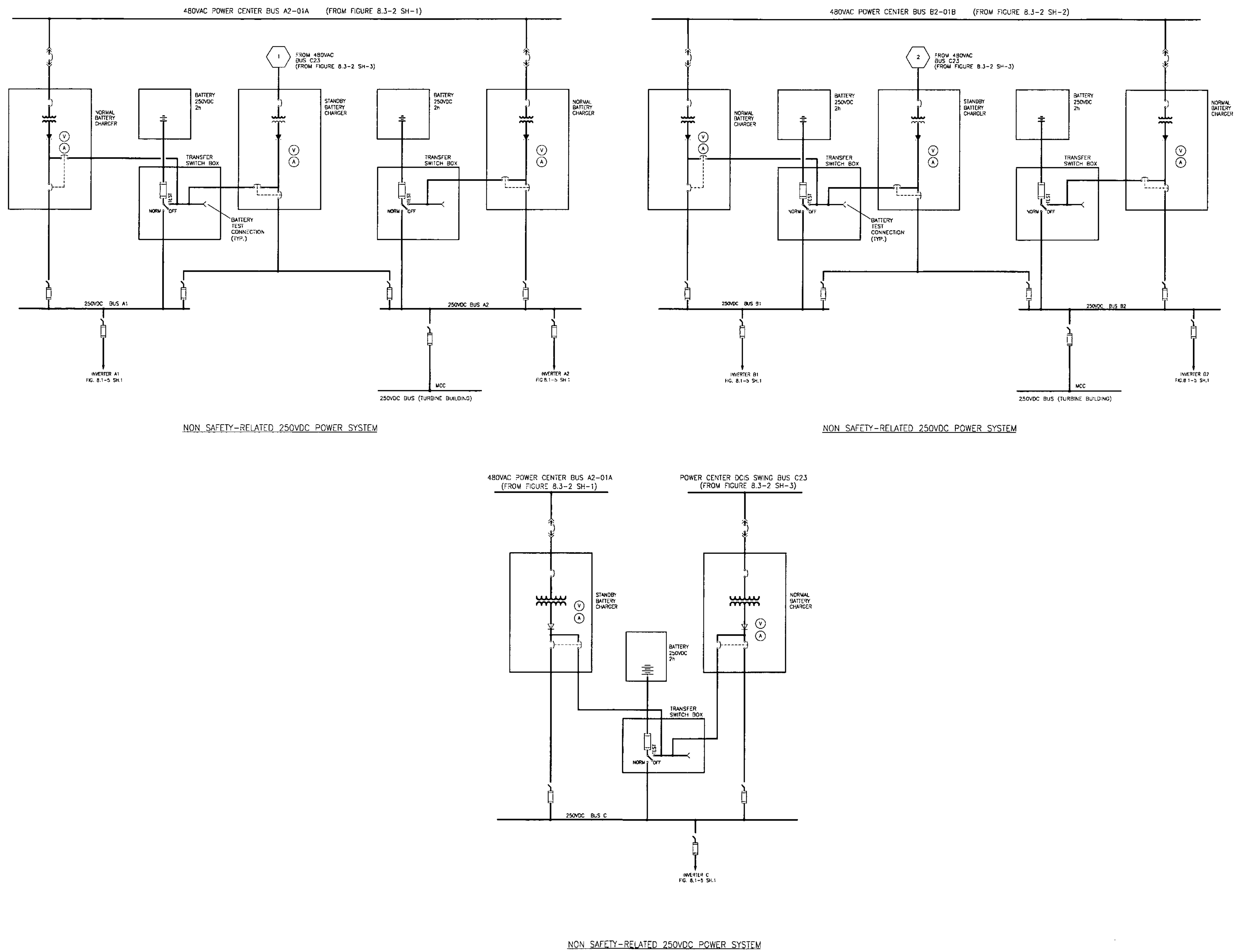

Figure 8.1-2. Direct Current Power Supply (Nonsafety-Related)
Sh 1 of 2

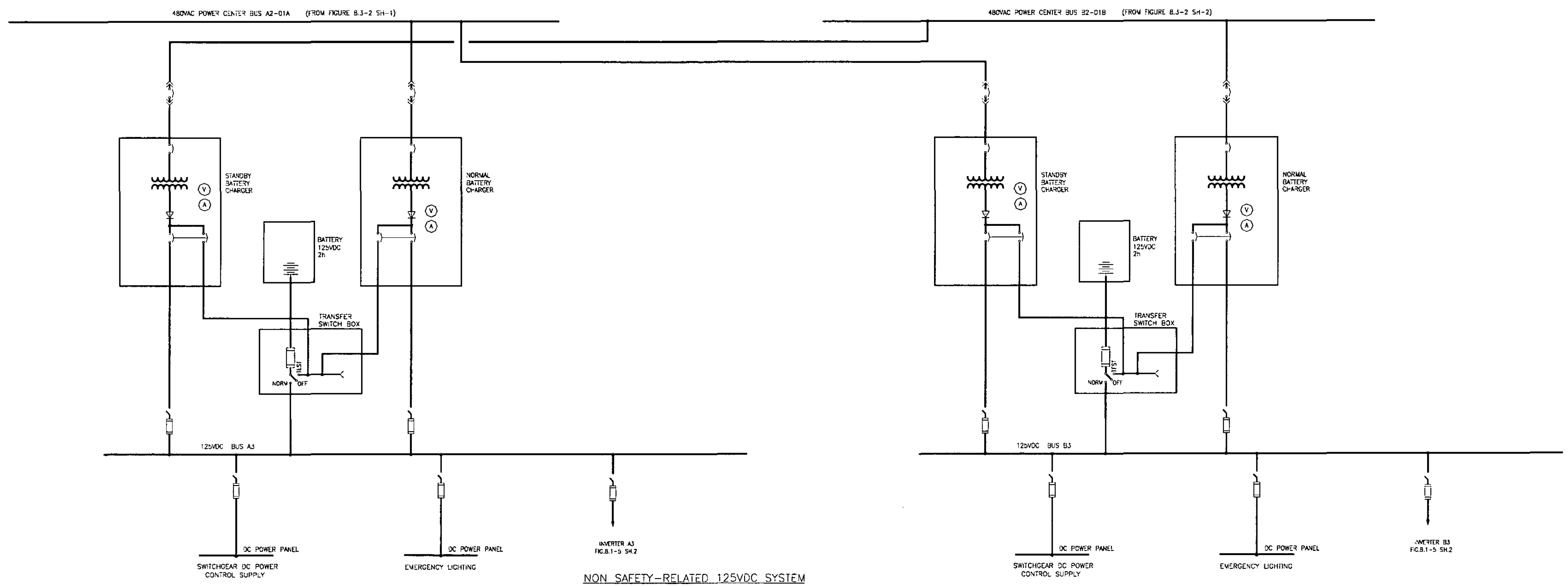

Figure 8.1-2. Direct Current Power Supply (Nonsafety-Related)

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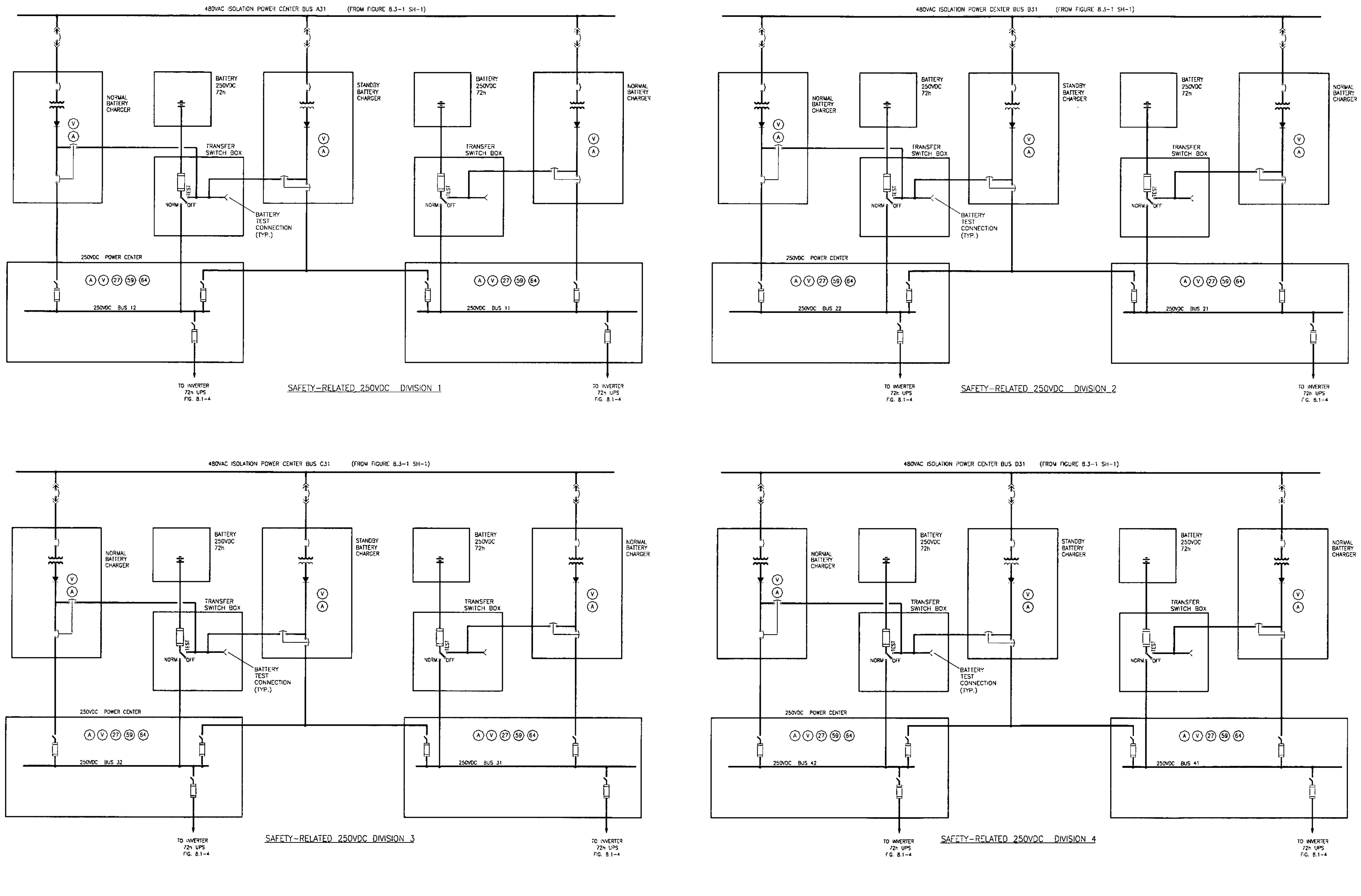

Figure 8.1-3. Direct Current Power Supply (Safety-Related)

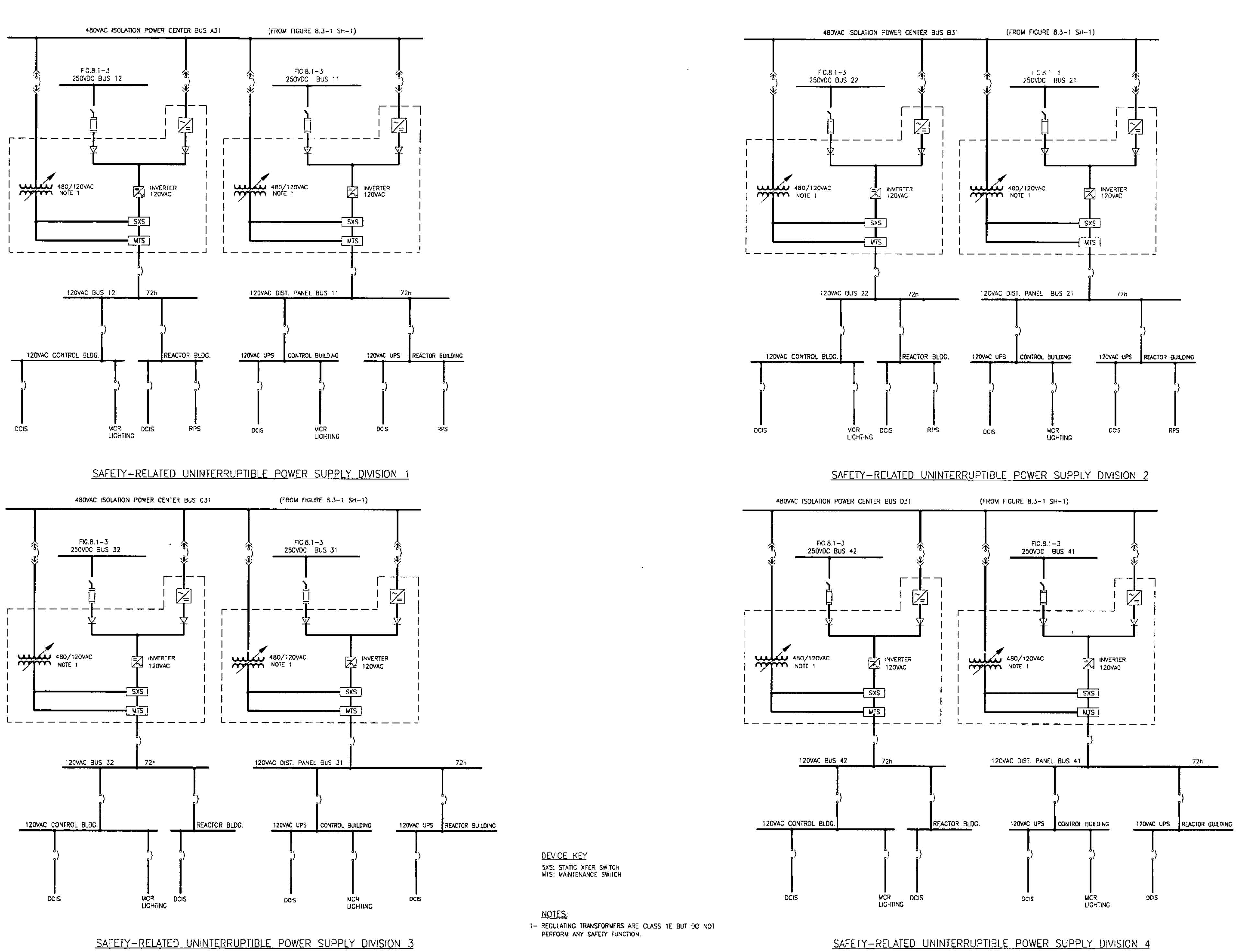

Figure 8.1-4. Uninterruptible AC Power Supply (Safety-Related)

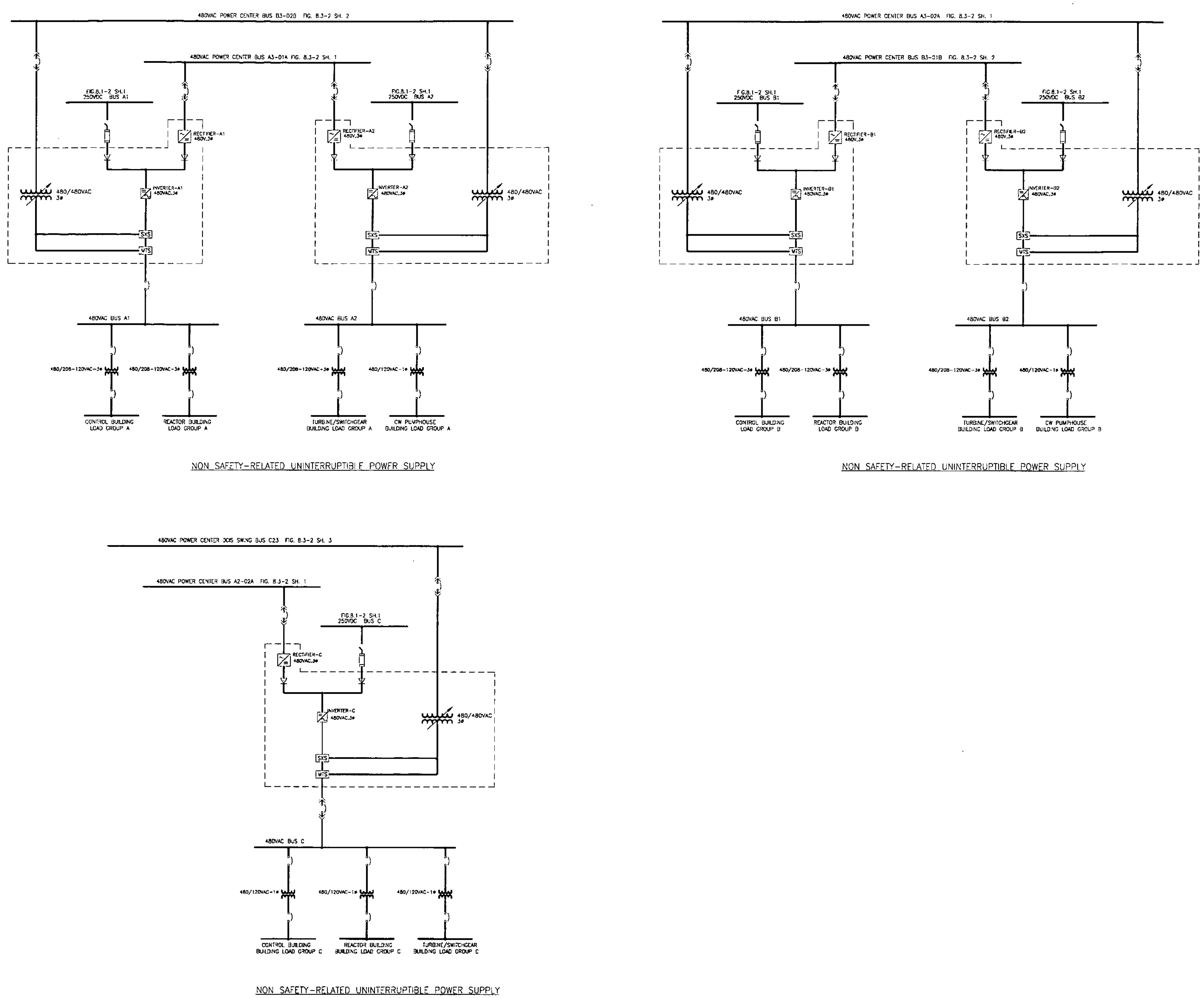

Figure 8.1-5. Uninterruptible AC Power Supply (Nonsafety-Related)
Sh 1 of 2

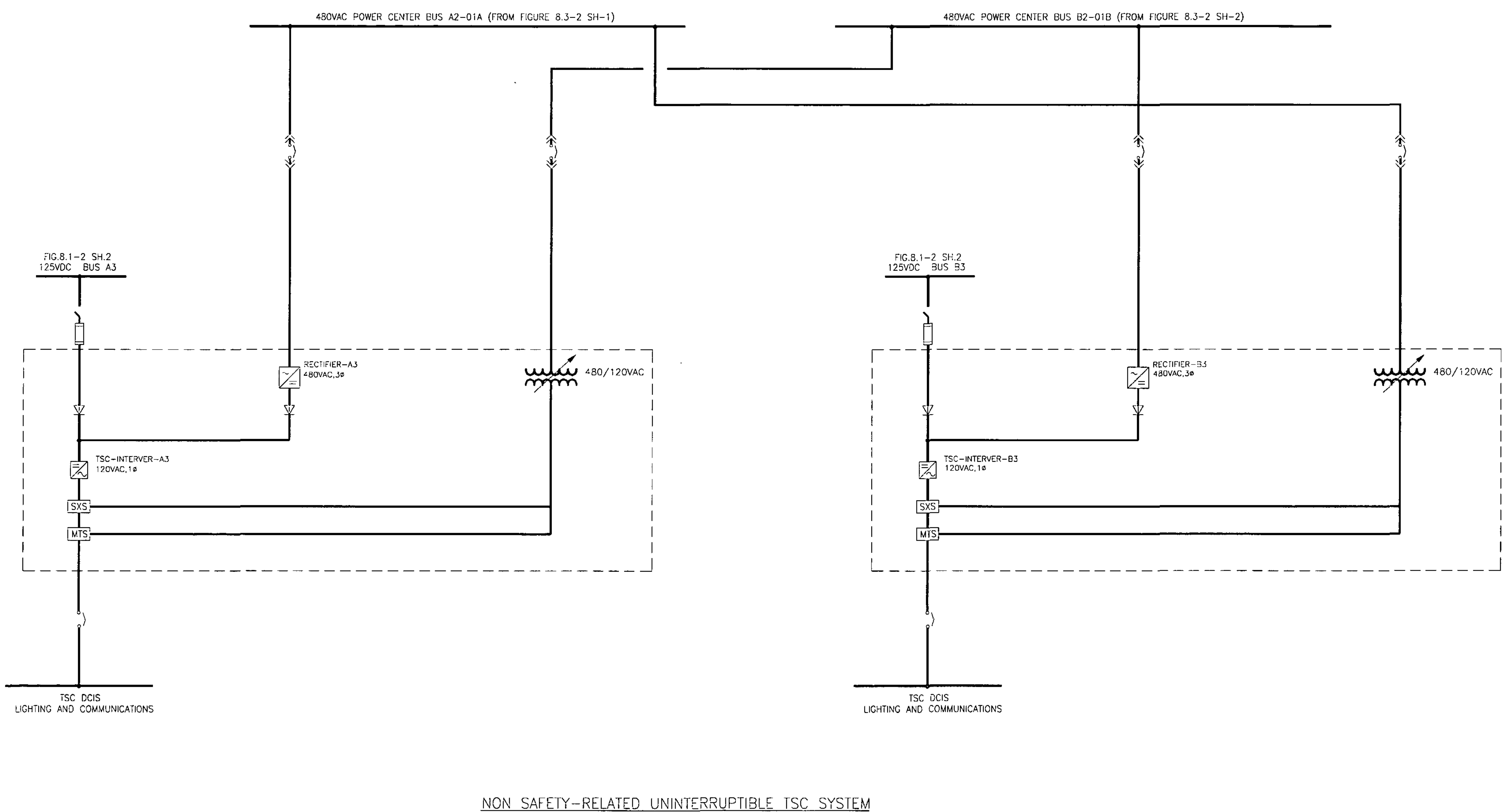

Figure 8.1-5. Uninterruptible AC Power Supply (Nonsafety-Related)
Sh 2 of 2

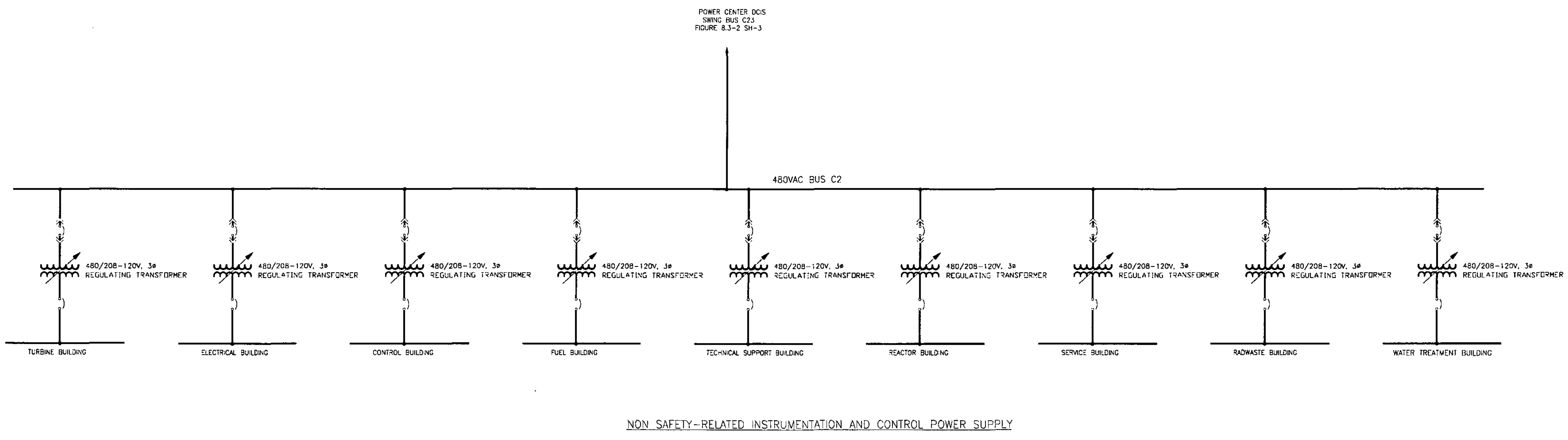

Figure 8.1-6. Instrumentation and Control Power Supply System (Nonsafety-Related)

Sh 1 of 1

- Regulatory Guide 1.47, "Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems," and BTP ICSB 21, "Supplemental Guidance for Bypass and Inoperable Status Indication for Engineered Safety Features Systems" – The offsite power system is nonsafety-related. Therefore, Regulatory Guide 1.47 and BTP ICSB 21 are not applicable to the ESBWR offsite power system.
- BTP ICSB 11, "Stability of Offsite Power Systems" – This topic is ~~site specific and~~ addressed in Subsection 8.2.2.1.

8.2.3 Design Bases Requirements

The offsite power system of the ESBWR Reference Plant is based on certain design bases 10 CFR 50.2 requirements. These design requirements follow:

- In case of failure of the normal preferred power supply circuit, the alternate preferred power supply circuit remains available.
- The normal preferred circuit and the alternate preferred circuit are electrically independent and are physically separated from each other. The normal preferred and the alternate preferred circuits are fed from separate transmission systems, each capable of supplying the shutdown loads. Both circuits may share a common switchyard but adequate separation exists.
- The switching station to which the main offsite circuit is connected has two full capacity main buses arranged such that:
  - Any incoming or outgoing transmission line can be switched without affecting another line.
  - Any circuit breaker can be isolated for maintenance without interrupting service to any circuit.
  - Faults of a single main bus are isolated without interrupting service to any circuit.
- Circuit breakers are sized and designed in accordance with IEEE Standard C37.06 (Reference 8.2-1). Disconnecting switches are sized and designed in accordance with IEEE Standard C37.32 (Reference 8.2-2).
- Cables associated with the normal preferred and alternate preferred circuits are routed separately and in separate raceways apart from each other and from onsite power system cables. However, they may share a common underground duct bank as indicated below.
- Associated control, instrumentation, and miscellaneous power cables of the alternate preferred circuit, if located underground in the same duct bank as cables associated with the normal preferred circuit between the switchyard and the power block, are routed in separate raceways.
- Interface protocols shall be established between the control room and the transmission operator, in accordance with the interconnection service agreement.
- Cables associated with the alternate preferred circuit are routed in trenches within the switchyard separate from cables associated with the normal preferred circuit.

8.3 ONSITE POWER SYSTEMS

8.3.1 AC Power Systems

8.3.1.1 Description

The main power transformer is within the onsite power system and consist of three single-phase transformers and an installed spare.

The UATs consist of two, three-phase transformers. The UATs provide normal preferred offsite power or main generator island mode power to each of the plant's two power generation load groups.

The RATs consist of two three-phase transformers fed from the alternate preferred offsite power source. The RATs provide alternate preferred power to the plant's two power generation load groups.

The RATs are of the same size as the UATs, and each functions as a backup power source in the event of a UAT failure.

The main power transformers, UATs and RATs, are designed and constructed to withstand the mechanical and thermal stresses produced by external short circuits, and meet the corresponding requirements of IEEE Standard C57.12.00 (Reference 8.3-12~~33~~).

An onsite main generator circuit breaker is provided with capability of interrupting the maximum available fault current. The main generator circuit breaker is sized and designed in accordance with IEEE Standard C37.013 (Reference 8.3-39) and IEEE Standard C37.010 (Reference 8.3-28). The main generator circuit breaker allows the generator to be taken off line and the main grid to be utilized as an immediate access power source for the onsite AC power system. Start-up power is normally provided through the UATs from the offsite power system.

The onsite isolated phase bus duct provides the electrical interconnection between the main generator output terminals and the low voltage terminals of the main transformers.

Onsite non-segregated phase bus duct provide for the electrical interconnection between the RATs and the 13.8 kV and 6.9 kV switchgear buses and are physically separated from the bus ducts provided for the interconnection of the UATs and the switchgear buses to minimize the likelihood of simultaneous failure.

Disconnect links are provided for the main transformers so that a failed transformer may be taken out of service and the installed spare connected.

Input isolation breakers (Reference 8.3-26), MODs, and disconnect links are provided for the UATs so that a failed transformer may be taken out of service. On loss of power from the UATs, 13.8 kV and 6.9 kV switchgear buses are automatically transferred to the RATs, which are connected to the alternate preferred power source.”

Disconnect links in addition to MODs are provided for the RATs so that a failed transformer may be taken out of service. Each of the connected RATs has the capability to replace one UAT.

There ~~will always be~~is always a normal or an alternate preferred power path to the safety-related electrical system if the plant is operating with a RAT in place of an out of service UAT.

The onsite AC power system consists of a 60 Hz standby onsite AC power supply system and various pieces of electrical distribution equipment. Figure 8.1-1 shows the plant main one line diagram. The onsite power distribution system has nominal bus voltage ratings of 13.8 kV, 6.9 kV, 480V, 208/120V and 240/120V. Throughout the discussion and on all the design drawings the equipment utilization voltages are designated as 13.8 kV, 6.9 kV, 480V, 208/120V and 240/120V.

The onsite AC power system is configured into two separate power load groups. Each power load group is fed by a separate UAT, each with a redundant RAT for backup, and consists of two types of buses:

- **Power Generation (PG) nonsafety-related buses** - are those buses that are not directly backed by standby onsite AC power sources and have connections to the normal or alternate offsite source through the UATs or RATs, respectively. The PG nonsafety-related buses are the 13.8 kV unit auxiliary switchgear and associated lower voltage load buses.
- **Plant Investment Protection (PIP) nonsafety-related buses** - are those buses that are backed by the standby onsite AC power supply system and have connections to the normal preferred and alternate preferred offsite sources through the UATs and RATs, respectively. Backfeed to the standby onsite AC power source is prevented by reverse power relaying. The PIP nonsafety-related buses are the 6.9 kV PIP buses and associated lower voltage load buses exclusive of the safety-related Isolation Power Center buses.

The PG nonsafety-related buses feed nonsafety-related loads required exclusively for unit operation and are normally powered from the normal preferred power source through the UATs. These buses are also capable of being powered from the alternate preferred power source (RATs), through an auto bus transfer, in the event that the normal preferred power source is unavailable. On restoration of UAT power, a manually selected bus transfer may be performed.

The PIP nonsafety-related buses feed nonsafety-related loads generally required to remain operational at all times or when the unit is shut down. In addition, the PIP nonsafety-related buses supply AC power to the safety-related buses. The PIP nonsafety-related buses are backed up by a separate standby ~~on-site~~onsite AC power supply system connected to each PIP bus. These buses are also capable of being powered from the alternate preferred power source (RATs), through an auto bus transfer, in the event that the normal preferred power source is unavailable. On restoration of UAT power, a manually selected bus transfer may be performed.

8.3.1.1.1 Medium Voltage AC Power Distribution System

The medium voltage AC power distribution system consists of the onsite electric power distribution circuits that operate at 13.8 kV and 6.9 kV. The system begins at the connection of the input terminals of the 13.8 kV and 6.9 kV feeder circuit breakers that are supplied power from the UATs and RATs, and at the output terminals of the plant onsite standby AC power sources. The system ends at the input terminals of medium voltage loads and at the low voltage terminals of the low voltage power center transformers. The system includes switchgear buses and circuit breakers as well as their associated local instrumentation, controls, and protective relays. It also includes cables or non-segregated buses interconnecting the switchgear buses to their sources and loads.

Power is supplied from the UATs and RATs at 13.8 kV and 6.9 kV to the PG and PIP buses. There are four PG buses, each being powered from one of the two UATs, or if the UATs are unavailable, from one of the two RATs. The source breakers for each PG bus are electrically interlocked to prevent simultaneous connection of UATs and RATs to the PG buses.

~~Two 6.9 kV PIP buses (PIP-A and PIP-B) provide power for the nonsafety-related PIP loads. PIP-A and PIP-B buses are each backed by a separate standby onsite AC power supply source.~~ Each PIP bus is normally powered from the normal preferred power source through the UAT of the same load group. Additionally, in the event of unavailability of the normal preferred power source, each PIP bus has connections to and can be powered from the alternate preferred power source through the RAT of the same load group. The source breakers of the normal and alternate preferred power sources are electrically interlocked to prevent simultaneous connection of UATs and RATs to the PIP buses under a faulted condition.

Standby AC power for the PIP nonsafety-related buses is supplied by standby diesel-generators at 6.9 kV and distributed by the nonsafety-related power distribution system. The 6.9 kV PIP buses are automatically transferred to the standby diesel-generators when the normal and alternate preferred power supplies to these buses are lost.

Each 13.8 kV and 6.9 kV bus has a safety grounding circuit breaker, not shown on the one line diagram, designed to protect personnel during maintenance operations. See Subsection ~~8.3.4.1~~13.5.1.

8.3.1.1.2 Low Voltage AC Power Distribution System

The low voltage AC power distribution system consists of the onsite electric power distribution circuits that operate at 480V through 120V, exclusive of plant lighting. For a discussion of the plant 120V systems refer to Subsections 8.3.1.1.3 and 8.3.1.1.4. The low voltage system begins at the low voltage terminals of the power center transformers . The system ends at the input terminals of loads (motors, heaters, etc.), at the input terminals of the battery chargers, and at the primary terminals of lighting transformers.

The low voltage AC power distribution system includes power centers, motor control centers (MCCs), distribution transformers, and distribution panels as well as the associated over current protective devices, protective relaying, and local instrumentation and controls. It also includes all cables interconnecting the buses to their sources and loads.

Power is supplied from the power center transformers to the 480V power centers. The power centers supply power to motor loads of approximately 100 kW through 249 kW, and to the 480V MCCs. The power centers are of the single-fed or double-ended type depending on the redundancy requirements of the loads powered by a given power center. The power supplies to the double-ended power center transformers of the PIP nonsafety-related buses are supplied from different buses. Each double-ended power center is normally powered by its normal power source through its normal source main breaker, with the alternate source main breaker open. The power center normal and alternate source main breakers are electrically interlocked to prevent simultaneous powering of the power center by normal and alternate sources.

Isolation Power Centers

The isolation power centers are powered from the PIP nonsafety-related buses, which are backed up by the standby diesel-generators. There are four isolation power centers, one each for

The four divisions of safety-related UPS are shown in Figure 8.1-4. The safety-related UPS buses are each supplied independently from their divisional safety-related inverters, which, in turn, are powered from one of the independent and redundant DC buses of the same division and from their isolation power center. The divisional DC bus is powered through a battery charger connected to its divisional isolation power center, and backed by the division's safety-related batteries. A static bypass switch is provided for transferring safety-related UPS AC load from the safety-related inverter output to a direct AC feed from the divisional isolation power center through a safety-related regulating transformer should an inverter failure occur. A manual bypass switch is provided for transferring safety-related UPS AC loads from the safety-related inverter output to a direct AC feed from the safety-related divisional isolation power center through a safety-related regulating transformer in order to perform inverter maintenance without removing safety-related UPS AC loads from service.

Routine maintenance can be conducted on equipment associated with the safety-related UPS power supply. Inverters, rectifiers, and solid state switches can be inspected, serviced and tested channel by channel without tripping the RPS logic.

UPS Components - Each of the four safety-related divisions includes the following safety-related UPS components:

- Two solid-state UPS rectifiers, to convert 480 VAC to 250 VDC
- Two solid-state UPS inverters, to convert 250 VDC to 120 VAC power;
- Two solid-state transfer switches to sense inverter failure and automatically switch to safety-related 480/120 VAC power;
- Two manual bypass switches for inverter or rectifier maintenance;
- Power distribution panel boards to provide power to all safety-related loads requiring uninterruptible 120 VAC power~~; and~~
- ~~Circuits between safety-related UPS components and from safety-related UPS components to safety-related UPS loads~~.

Operating Configuration - The four divisions of safety-related UPS operate independently, providing power to all safety-related loads within their division requiring uninterruptible AC power. The normal power source for each division's inverter is the same division's isolation power center, which provides AC power to the rectifier. Transfer from the 480 VAC power supply to the 250 VDC bus is done automatically and passively in case of loss of the normal power source. Transfer from the inverter to the alternate AC source (provided via the division's isolation power center through a regulating transformer) is done automatically in case of inverter failure. An alarm is provided in the control room for any of the alternate operating lineups.

Nonsafety-Related Uninterruptible Power Supply System

The nonsafety-related UPS provides reliable, uninterruptible AC power for nonsafety-related equipment needed for continuity of power plant operation. UPS loads are divided into three load groups. Each UPS load group includes a solid-state inverter, solid-state rectifier, solid-state transfer switch, manual transfer switch, and ~~distribution~~regulating transformer~~s~~ with associated distribution panels (Figure 8.1-5~~ Sh 1 of 2~~).

The normal power supply for ~~each of~~ the ~~two~~A and B load groups of the nonsafety-related UPS is through a nonsafety-related 480 VAC power center fed from the A and B PIP buses, respectively.~~, with backup power provided by the standby on-site AC power supply system PIP bus of the same load group~~. In case of failure of the 480 VAC power supply, transfer from the 480 VAC power center to the nonsafety-related 250 VDC bus is automatic and passive. Transfer from the normal AC power source through the inverter to the alternate AC power source occurs by automatic static transfer should an inverter failure occur. An alarm in the main control room sets off when an alternate lineup of the nonsafety-related UPS occurs.

The 480 VAC power centers, which provide power to the nonsafety-related battery chargers, are connected to PIP nonsafety-related buses that are backed up by standby diesel-generators.

A third nonsafety-related UPS is provided to supply additional nonsafety-related loads that require uninterruptible power. This UPS is normally powered from 480 VAC power centers, which receive power from the diesel-backed PIP-A bus. Should a failure of the normal power supply occur, the alternate power supply to the UPS is from the 250 VDC bus. During loss of normal and alternate power supply or inverter failure, loads continue to get power from the 480 VAC DCIS double-ended (PIP-A or PIP-B) Swing Bus, which also supplies power during maintenance of the inverter and its associated components.~~A third nonsafety-related UPS is provided to supply the nonsafety-related DCIS loads. This load group's nonsafety-related UPS is normally powered from a 480 VAC double-ended power center, which can receive power from either of the two power load groups. The power center normal and alternate source main breakers are electrically interlocked to prevent the normal and alternate sources from simultaneously providing power to the power center. Additionally, standby onsite AC power from either of the two load groups provides backup power should a failure of the normal and alternate supplies occur. Emergency power of the same load group from 250 VDC batteries is provided should loss of normal, alternate, and standby onsite AC power sources occur.~~

Two dedicated nonsafety-related UPS (Figure 8.1-5~~-Sh 2 of 2~~) are provided for the Technical Support Center (TSC), also in a two-load group configuration. Power for each TSC nonsafety-related UPS is normally supplied from a 480 VAC power center in the same load group, with standby ~~on-site~~onsite AC power of the ~~same~~ opposite load group providing backup power should a failure of the normal supply occur. Backup DC power of the same load group from 125 VDC batteries is provided should loss of normal and standby onsite AC power sources occur.

8.3.1.1.4 Instrumentation and Control Power Supply System

Figure 8.1-6 shows the overall Instrumentation and Control Power Supply System.

Regulating step-down transformers provide 208/120 VAC power to those loads not requiring uninterruptible power. The nonsafety-related AC control power buses are shown in Figure 8.1-6. The Instrumentation and Control buses are each supplied independently from the~~separate~~ 480 VAC ~~power centers~~ DCIS Swing Bus.

Instrumentation and control buses are supplied from the DCIS Swing Bus~~SWING BUS~~ power center to supply nonsafety-related I&C loads that do not require uninterruptible power.~~ This system supplies AC loads to the Nonsafety-Related Distributed Control and Information System, solenoid valves and other I&C loads.~~

The Instrumentation and Control Power Supply System does not perform any safety-related function.

8.3.1.1.5 Safety-Related Electric Equipment Considerations

The following guidelines are utilized for safety-related equipment.

Physical Separation and Independence:

- Electrical equipment is separated in accordance with IEEE Standard 384, Regulatory Guide 1.75 and General Design Criterion 17.
- To meet the provisions of Policy Issue SECY-89-013, which relates to fire tolerance, 3 hour rated fire barriers are provided between areas of different safety-related divisions throughout the plant except in the primary containment and the control room complex. Refer to Subsection 9.5.1 for a description of how the provisions of the policy issue are met.
- The overall design objective is to locate the divisional equipment and its associated control, instrumentation, electrical supporting systems, and interconnecting cabling such that separation is maintained between all divisions. Redundant divisions of electric equipment and cabling are located in separate rooms or fire areas wherever possible.
- Electric equipment and wiring for the safety-related systems which are segregated into separate divisions are separated so that no design basis event is capable of disabling more than one division of any engineered safety feature (ESF) total function.
- The safety-related electrical equipment (batteries, distribution panels, etc.) are located in separate seismic Category I rooms in the reactor building to ensure electrical and physical separation among the divisions. Separation is provided between divisional cables being routed between various equipment rooms, the main control room, containment, and other processing areas. Separation of safety-related equipment in these areas is achieved by separate safety-related structures, barriers, or a combination thereof. The equipment is located to facilitate divisional separation of cable trays and to provide access to electrical penetration assemblies. Exceptions to this separation objective are identified and analyzed as to equivalency and acceptability in the fire hazard analysis (see Section 9A.6 Special Cases). For separation requirements relating to the main control room and relay panels, refer to "Main Control Room and Relay Panels" in Subsection 8.3.1.4.
- For separation requirements relating to the wiring and components within control, relay, and instrument panels/racks, refer to "Control, Relay, and Instrument Panels/Racks" in Subsection 8.3.1.4
- For additional separation requirements relating to RPS and ESF systems refer to "System Separation Requirements" in Subsection 8.3.1.4. Containment electrical penetrations are dispersed around the periphery of the containment and are physically separated in accordance with the requirements of Section 6.5 of IEEE 384 (Reference 8.3-10). Each penetration carries circuits of a single voltage class and division. Penetrations serving safety-related loads are not used for nonsafety-related circuits and are only used for circuits belonging to the same safety-related division.

- Wiring for all safety-related equipment indicating lights is an integral part of the safety-related cables used for control of the same equipment and are considered to be safety-related circuits.

Class 1E Electric Equipment Design Bases and Criteria:

- Plant design specifications for electrical equipment require such equipment be capable of continuous operation with equipment terminal voltage fluctuations of plus or minus 10% of rated voltage.
- Power sources, distribution systems, and branch circuits are designed to maintain voltage and frequency within acceptable limits.
- Interrupting capacity of distribution panels is at least equal to the maximum available fault current to which it is exposed under all modes of operation. Circuit breaker and applications are in accordance with ANSI Standards.
- Refurbished circuit breakers ~~shall not be~~are not used in either safety-related or nonsafety-related circuitry of the ESBWR design. New circuit breakers ~~shall be~~are specified in all ESBWR purchase specifications. (NRC Bulletin No. 88-10 and NRC Information Notice No. 88-46 identify problems with defective refurbished circuit breakers.)

Testing:

The design provides for periodically testing the chain of system elements from sensing devices through actuated equipment to ensure that safety-related equipment is functioning in accordance with design requirements, and to ensure that the requirements of Regulatory Guide 1.118 and IEEE 338 (Reference 8.3-10) are met.~~ Refer to Subsection 8.3.4.2.~~

8.3.1.1.6 Circuit Protection

Philosophy of Protection

Simplicity of load grouping facilitates the use of conventional, protective relaying practices for isolation of faults. Emphasis has been placed on preserving function and limiting loss of safety-related equipment function in situations of power loss or equipment failure.

Protective relay schemes and direct acting trip devices are provided throughout the ~~on-site~~onsite power system to:

- Isolate faulted equipment and/or circuits from the power system;
- Prevent damage to equipment;
- Protect personnel;
- Minimize system disturbances; and
- Maintain continuity of the power supply.

Grounding

The ESBWR grounding ~~will comply~~complies with guidelines provided in Section 8A.1 ~~(IEEE 665 and IEEE 1050)~~.

Bus Protection

Bus protection for nonsafety-related and safety-related buses are as follows:

- The 13.8 kV and 6.9 kV bus incoming circuits have inverse-time overload, ground fault, bus differential, under voltage, and degraded voltage protection;
- The 13.8 kV and 6.9 kV feeders for power centers have instantaneous, inverse-time overload and ground fault protection;
- The 13.8 kV and 6.9 kV motor feeders have instantaneous, inverse-time overload and ground fault protection;
- The 480V feeders for MCC buses have long-time and short-time overload and ground fault protection;
- The 480V Isolation Power Center buses have inverse-time overload and ground fault protection. In addition, loss of voltage, degraded voltage and under-frequency relay protective functions are provided which isolate these buses from the nonsafety-related system upon degraded source conditions; and
- The 480V MCC loads (nonsafety-related only, there are no safety-related 480 VAC MCC loads) have instantaneous and inverse time overload protection.

Protection Requirements

When the standby onsite AC power sources are called upon to operate, all the protective relay functions identified in "Protection Systems" (Subsection 8.3.1.1.8) are available.

8.3.1.1.7 Load Shedding and Sequencing on PIP Buses

Load shedding, bus transfer and sequencing on the 6.9 kV PIP buses is initiated on loss of bus voltage. Loss of Normal Preferred Power may cause load shedding and sequencing with an auto transfer to Alternate Preferred Power. If Alternate Preferred Power is not sensed by protective relaying, power ~~will be~~is supplied by the appropriate onsite standby diesel power source.

PIP bus ready-to-load signals are generated by the protective relaying logic and control system for the electric power distribution system.

Diesel Generators are sized conservatively to accommodate expected loads to be served by them with an acceptable starting sequence.

LOPP

The 6.9 kV PIP buses are normally energized from the normal preferred power supply. When the normal preferred power supply is lost, an auto transfer from the normal preferred power supply to the alternate preferred power supply is made.

Should the normal and alternate preferred power supplies protective relaying sense loss of power the incoming PIP buses feeder breakers ~~will~~ trip. Large pump motor breakers are tripped and low voltage motor starters are opened due to under voltage. A standard dead bus transfer is automatically initiated to the standby ~~on-site~~onsite AC power source. The signal starts the standby ~~on-site~~onsite AC power source, and closes the standby power supply breaker after the standby ~~on-site~~onsite AC power source has returned a ready to load signal (i.e., voltage and frequency are within normal limits and no lockout exists, and the normal and alternate preferred supply breakers are open). After bus voltage has been reestablished, large motor loads are sequence started as required. Transfer back to the preferred power source is a synchronized closure of the feeder breaker by manual action to the selected source.

Loss-of-Coolant Accident (LOCA)

When a LOCA occurs without a LOPP there is no effect on the electrical distribution system. The plant remains on either source of preferred power and the onsite diesel-generator is not started. The load shed and sequence timers are not activated.

LOPP Following LOCA

If the bus voltage (normal and alternate preferred power) is lost during post-accident operation, transfer to the standby onsite AC power source occurs as described in LOPP, above.

LOCA Following LOPP

If a LOCA occurs following loss of both the normal and alternate preferred power supplies, the standby onsite AC power source should have already started from low bus voltage. Automatic load sequencing shall ~~already~~ have started as described in LOPP, above.

LOCA When the Standby Onsite AC Power Source is Parallel to the Power Source During Testing

If a LOCA occurs when the standby diesel-generator is paralleled with either the normal preferred power or the alternate preferred power source, the standby diesel-generator automatically disconnects from the 6.9 kV PIP bus regardless of whether the test is being conducted from the local control panel or the main control room.

Loss of Normal Preferred Power Source During Standby Onsite Power Source Paralleling Test

If the normal preferred power supply is lost during the standby onsite AC power source paralleling test, the normal preferred power supply breaker and diesel generator breaker are automatically tripped and the alternate preferred power source accepts loads to re-energize the selected bus loads. Transfer back to the normal preferred power supply may then be accomplished manually.

Loss of Alternate Preferred Power Source During Standby Onsite Power Source Paralleling Test

If the alternate preferred supply is used for load testing the standby onsite AC power source, and the alternate preferred source is lost, the alternate preferred power supply breaker and diesel-generator breaker are automatically tripped and the AC power source may then be transferred back to the normal preferred power supply manually.

Restoration of Offsite Power

Upon restoration of offsite power, the 6.9 kV PIP buses can be transferred back to the offsite source by manual operation only, as described above in LOPP.

8.3.1.1.8 Standby Onsite AC Power Supply System

The standby AC power supply system is not within the ESBWR 10 CFR 50.2 Design Bases, is not relied upon to perform any safety-related function or achieve safe shutdown, and thus, is classified as nonsafety-related. It includes the standby onsite AC power sources and associated power supply circuits up to the source breakers of the onsite PIP buses to which they are connected.

The standby onsite AC power sources consist of the prime movers and AC generators, the auxiliary systems (starting, lubrication, cooling, fuel supply, excitation, etc.), the fuel storage and transfer systems and the associated local instrumentation and control systems. (Refer to Subsections 9.5.4, 9.5.5, 9.5.6, 9.5.7, 9.5.8, and 9.4.7.)

The onsite standby AC power supply system is designed to supply AC power to the PIP nonsafety-related buses. The PIP buses provide power for various auxiliary and investment protection load groups, and isolation power centers when the normal and alternate preferred power supplies are not available. Operation of the system is not required to ensure safe shutdown.

Figure 8.1-1 shows the interface between the normal preferred power sources, alternate preferred power sources, and the standby onsite AC power sources.

Redundant (non-safety) Standby AC Power Supplies

Each standby power system load group, including the standby diesel-generator, its auxiliary systems, and the distribution of power through the 6.9 kV and lower voltage PIP buses to various investment protection load groups, is segregated and separated from the redundant load group. No interconnection is provided between the redundant standby power system load groups. Each standby ~~on-site~~onsite AC power source is operated independently of the other standby onsite AC power source and is connected to the utility power system by manual control during testing or for bus transfer.

Ratings and Capability

Each of the standby onsite AC power sources is sized to serve its nonsafety-related load and conforms to the following criteria:

- Each standby onsite AC power source is capable of starting, accelerating, and supplying its loads in the sequence necessary for plant investment protection.
- Each standby onsite AC power source is capable of starting, accelerating, and supplying its loads in their proper sequence without exceeding an unacceptable voltage drop at its output terminals.
- Each standby onsite AC power source is capable of reaching full speed and voltage within 1 minute after receiving a signal to start, and is capable of being fully loaded within an acceptable time that ~~will~~ does not challenge the diesel generator capacity.
- Each standby onsite AC power source has a continuous power rating greater than the sum of the loads of its load group of PIP loads and safety-related battery chargers that could be powered concurrently during hot standby, normal plant cool down, or plant outages.

- The generator exciter and voltage regulator systems are capable of providing full voltage control during operating conditions including expected transients.

Starting Circuits and Systems

The standby onsite AC power sources start automatically on loss of bus voltage. Under-voltage relays ~~will~~ initiate the sequence used to start each standby onsite AC power source.

Upon loss of preferred AC power (normal and alternate) to the PIP buses, the transfer of these buses to the standby onsite AC power sources is automatic. After the breakers connecting the buses to the preferred power supply (or alternate preferred power supply, depending upon system configuration) are opened and when the required standby onsite AC power source generator voltage and frequency are established, the standby onsite AC power source breaker is closed.

Automatic Shedding, Loading and Isolation

The standby onsite AC power source is connected to its PIP bus only when the incoming preferred and/or alternate preferred source breakers have been tripped, except during parallel load testing using the normal or alternate preferred power sources (see Subsection 8.3.1.1.7).

Protection Systems For Diesel Generators

The onsite standby generator is shut down and the generator breaker tripped under the following conditions during all modes of operation and testing:

- Generator over speed trip;
- Reverse power relay trip;
- Field relay trip;
- Over current relay trip;
- Over voltage relay trip;
- Ground relay trip;
- Over temperature relay trip;
- Under voltage relay trip;
- Frequency relay trip; and
- Generator differential relay trip.

These protective functions of the standby onsite AC power source or the generator breaker and other off-normal conditions are alarmed and/or indicated in the main control room (see Table 8.3-1).

Local and Remote Control

Each standby onsite AC power source is capable of being started or stopped manually from the main control room. Start/stop control and bus transfer control may be transferred to a local control station in the standby onsite AC power source room by operator action.

Engine Mechanical Systems and Accessories

Descriptions of these systems and accessories are given in Section 9.5.

- During plant shutdown, testing of the operability of the safety-related system as a whole. Under conditions, as close to design as practicable, the full operational sequence that brings the system into operation, including operation of signals of the safety-related systems and the transfer of power between offsite and onsite power system, are able to be tested.

GDC 50, Containment Design Basis

GDC 50, as it relates to the design of circuits using containment electrical penetration assemblies, is met as indicated in Subsection 8.1.5.2.4.

8.3.1.2.2 Quality Assurance Requirements

The Quality Assurance program is provided in Chapter 17. This program includes a comprehensive system to ensure that the purchased material, manufacture, fabrication, testing, and quality control of the equipment conforms to the GE Quality Assurance program. The administrative responsibility and control provided are also described in Chapter 17.

These Quality Assurance requirements include an appropriate vendor quality assurance program and organization, purchaser surveillance as required, vendor preparation and maintenance of appropriate test and inspection records, certificates and other quality assurance documentation, and vendor submittal of quality control records considered necessary for purchaser retention to verify quality of completed work.

A necessary condition for receipt, installation and placing of equipment in service ~~has been~~is the citing and auditing of Quality Assurance/Quality Control (QA/QC) verification data and the placing of this data in permanent onsite storage files.

8.3.1.2.3 Environmental Considerations

In addition to the effects of operation in a normal service environment, all safety-related equipment is designed to operate during and after any design basis event, in the area in which it is located. All safety-related electric equipment in a harsh environment is qualified to IEEE 323. Detailed information on all safety-related equipment that must operate in a harsh environment during and/or subsequent to an accident is provided in Section 3.11.

8.3.1.3 Physical Identification of Safety-Related Equipment

8.3.1.3.1 Power, Instrumentation and Control Systems

Electrical and control equipment, panels and racks, and cables and raceways grouped into separate divisions are identified so that their electrical divisional assignment is apparent, and so that an observer can visually differentiate between safety-related equipment and wiring of different divisions, and between safety-related and nonsafety-related equipment and wiring. The identification method is color-coding. All markers within a division have the same color. The ESBWR standard plant design ~~will~~ eliminates safety-related associated circuits as defined by IEEE 384 and in accordance with RG 1.75. Divisional separation requirements of individual pieces of hardware are shown in the system elementary diagrams. Identification of raceways, cables, etc., is compatible with the identification of the safety-related equipment with which it interfaces. Location of the identification is such that points of change of circuit classification (at isolation devices, etc.) are readily apparent.

8.3.1.4 Independence of Redundant Systems

8.3.1.4.1 Power Systems

The safety-related onsite electric power systems and major components of the separate power divisions are shown in Figures 8.1-3 and 8.1-4.

Independence of the electric equipment and raceway systems, between the different divisions, is maintained primarily by firewall-type separation, where feasible, and by spatial separation, in accordance with criteria given within this subsection, "Safety-Related Electric Equipment Arrangement." Exceptions are analyzed in Appendix 9A.6.4, "Fire Separation for Divisional Electrical Systems".

Where spatial separation cannot be maintained in hazardous areas (e.g., potential missile areas), physical isolation between electrical equipment of different divisions is achieved by use of a protective barrier designed to withstand the effects of postulated hazards.

The physical independence of electric power systems complies with the requirements of IEEE Standard 384, GDC 17, and NRC Regulatory Guide 1.75.

Safety-Related Electric Equipment Arrangement

Safety-related electric equipment and wiring are segregated into separate divisions so that no single credible event is capable of disabling enough equipment to hinder reactor shutdown, removal of decay heat from the core, or isolation of the containment in the event of an accident. Separation requirements are applied to control power and motive power for all systems involved.

Equipment arrangement and/or protective barriers are provided such that no locally generated force or missile can destroy any redundant RPS, Nuclear Steam Supply Systems (NSSS), ESF, or ECCS functions.

Routing of wiring/cabling is arranged such as to eliminate, to the extent practical, all potential for fire damage to cables and to separate the redundant divisions so that fire in one division does not propagate to another division.

An independent raceway system is provided for each division of the safety-related electric system. The raceways are arranged, physically, top to bottom based on the function and the voltage class of the cables.

Electric Cable Installation

Cable derating and cable tray fill — Base ampacity rating of cables is established as described in Subsection 8.3.3.2. Cables are installed in trays in accordance with their voltage ratings and as described in this Subsection ~~8.3.1.4.1~~. Tray fill is as established in ~~this~~ Subsection 8.3.3.2.

Cable routing in potentially harsh environmental areas — Circuits of different safety-related divisions that are routed through the same potentially harsh environmental area are protected through separation by conduit and armored cable and by qualifications described in Subsection 8.3.3.2.

Sharing of cable trays — Each division of safety-related AC and DC system cables is provided with its own independent and separate raceway system.

those necessary to mitigate the effects of anticipated and abnormal operational transients or design basis accidents. This includes safety-related systems and functions enumerated in Chapter 7. The term "systems" includes the overall complex of actuated equipment, actuation devices (actuators), logic, instrument channels, controls, and interconnecting cables that are required to perform system safety-related functions. The criteria outline the separation requirements necessary to achieve independence of safety-related functions compatible with the redundant and/or diverse equipment provided and postulated events.

General

Separation of the equipment for the safety-related systems referred to in Chapter 7 is accomplished so that they are in compliance with IEEE 603 (Reference 8.3-33), 10 CFR 50 Appendix A, GDC 3 and 17, and NRC Regulatory Guides 1.75 (IEEE 384) and 1.53 (IEEE 379).

Independence of mutually redundant and/or diverse safety-related equipment, devices, and cables is achieved by spacial separation, barriers, and electrical isolation. This protection is provided to maintain the independence of safety-related circuits and equipment so that the protective function required during and following a design basis event including a single fire anywhere in the plant or a single active failure in any circuit or equipment with one division out of service can be accomplished with the remaining two divisions.

Separation Techniques

The methods used to protect redundant safety-related systems from results of single active failures or events are utilization of safety-related structures, spatial separation, 3-hour rated fire barriers, and isolation devices.

Safety-Related Structures — The basic design consideration in plant layout is that redundant circuits and equipment are located in separate safety-related areas and fire areas to the extent possible. The separation of safety-related circuits and equipment is such that the required independence is not compromised by the failure of mechanical systems served by the safety-related electrical system. For example, safety-related circuits are routed or protected so that failure of related mechanical equipment of one system cannot disable safety-related circuits or equipment essential to the operation of a redundant system.

Spatial Separation and/or Protective Barriers — Spatial (distance) separation and/or protective barriers are such that no locally generated force or missile resulting from a design basis ~~event~~accident (~~DBE~~DBA) or from random failure of equipment can disable a redundant safety-related function. Separation in all safety-related equipment and cable areas ~~shall~~ equals or exceeds the requirements of IEEE 384.

Main Control Room and Relay Panels — The protection system and safety-related control, logic, and instrument panels/racks are located in a safety-related structure in which there are no potential sources of missiles or pipe breaks that could jeopardize redundant cabinets and raceways.

Control, Relay, and Instrument Panels/Racks — Control, relay, and instrument panels/racks are designed in accordance with the following general criteria to preclude failure of nonsafety-related circuits causing failure of any safety-related circuit, and to preclude failure of any safety-related circuit causing failure of its redundant safety-related circuit. Single panels or instrument

(9) Inputs from safety-related equipment or circuits are safety-related and retain their divisional identification up through their safety-related isolation device. The output circuit from this isolation device supports a nonsafety-related function.

8.3.2 DC Power Systems

8.3.2.1 Description

Completely independent safety-related and nonsafety-related DC power systems are provided. The safety-related DC system is shown in Figure 8.1-3. The nonsafety-related DC system is shown in Figure 8.1-2.

Eight independent safety-related 250 VDC systems are provided, two each for Divisions 1, 2, 3 and 4. They provide four divisions of independent and redundant onsite sources of power for operation of safety-related loads, monitoring and MCR emergency lighting.

Five independent nonsafety-related DC systems are provided consisting of three 250 VDC systems and two 125 VDC systems. The nonsafety-related DC systems supply power for control and switching, switchgear control, TSC, instrumentation, and station auxiliaries.

Battery duty cycles are shown in Table 8.3-2.

8.3.2.1.1 Safety-Related Station Batteries and Battery Chargers

250V Safety-Related DC Systems Configuration

Figure 8.1-3 shows the overall 250 VDC system provided for safety-related Divisions 1, 2, 3 and 4. Divisions 1, 2, 3 and 4 consist of two separate battery sets for each division. Each set supplies power to the safety-related inverters for at least 72 hours following a design basis event. The DC systems are operated ungrounded for increased reliability. Each of the safety-related battery systems has a 250 VDC battery, a battery charger, a main distribution panel, and a ground detection panel. One divisional battery charger is used to supply each group DC distribution panel bus and its associated battery. The divisional battery charger is fed from its divisional 480V Isolation Power Center. The main DC distribution bus feeds the UPS inverter. Each division has a standby charger to act as a backup to either of the batteries of that division.

The four safety-related divisions are supplied power from four independent Isolation Power Centers. The 250 VDC systems supply DC power to Divisions 1, 2, 3 and 4, respectively, and are designed as safety-related equipment in accordance with IEEE 308 (Reference 8.3-38) and IEEE 946 (Reference 8.3-1). The safety-related DC system is designed so that no single active failure in any division of the 250 VDC system results in conditions that prevent safe shutdown of the plant while a separate division has been taken out of service for maintenance.

The plant design and circuit layout of the DC systems provide physical separation of the equipment, cabling, and instrumentation essential to plant safety. Each 250 VDC battery is separately housed in a ventilated room apart from its charger, distribution, and ground detection panels. Equipment of each division of the DC distribution system is located in an area separated physically from the other divisions. All the components of safety-related 250 VDC systems are housed in Seismic Category I structures.

8.3.2.2 Analysis

8.3.2.2.1 Safety-Related DC Power Systems

The 480 VAC power supplies for the divisional battery chargers are from the individual Isolation Power Centers to which the particular 250 VDC system belongs (Figure 8.1-3). These Isolation Power Centers are fed directly from the PIP nonsafety-related buses, which are backed up by the standby diesel generators. In this way, separation between the independent systems is maintained and the AC power provided to the chargers can be from either preferred or standby AC power sources.

The DC system is arranged so that the probability of an internal system failure resulting in loss of that DC power system is extremely low. A ground detection system is employed for prompt detection of grounds. Important system components are either self-alarming on failure, or capable of clearing faults, or being tested during service to detect faults. Each battery set is located in its own ventilated battery room. All abnormal conditions of important system parameters such as system grounds, charger failure and low bus voltage are alarmed in the main control room and/or locally.

8.3.2.2.2 Regulatory Requirements and Guides

The following analyses demonstrate compliance of the safety-related Divisions 1, 2, 3 and 4 DC power systems to NRC GDC, NRC Regulatory Guides, and other criteria consistent with the SRP. The analyses establish the ability of the system to sustain credible single active failure with one division already out of service and the remaining two divisions retain their capacity to function for 72 hours before requiring recharge.

The following list of criteria is addressed in accordance with Table 8.1-1, which is based on Table 8-1 of the SRP. In general, the ESBWR is designed in accordance with all criteria. Any exceptions or clarifications are so noted.

GDC:

GDC 2, 4, 17, 18 and 50 - The DC power system complies with these GDC, which are generically addressed in Subsection 8.1.5.2.4~~3.1.2~~.

Regulatory Guides:

Regulatory Guide 1.6 — "Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems." The ESBWR Standard Plant does not need or have any safety-related standby AC power sources, therefore this Regulatory guide is not applicable to the ESBWR design (see Table 8.1-1). However, the ESBWR offsite and onsite nonsafety-related power sources do comply with independence and redundancy between their sources and distribution systems

Regulatory Guide 1.32 — "Criteria for Power Systems for Nuclear Power Plants." Safety-related DC power sources are provided to support passive core cooling and containment integrity safety functions. No offsite or diesel-generator-derived AC power is required for 72 hours.

Regulatory Guide 1.47 — "Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems."

Regulatory Guide 1.53 – "Application of the single failure criteria in nuclear power plants."

Regulatory Guide 1.63 — "Electric Penetration Assemblies in Containment Structures for Nuclear Power Plants."

Regulatory Guide 1.75 — "Physical Independence of Electric Systems." Safe shutdown relies only upon DC-derived power and ~~will~~ meets the design requirements for physical independence.

Regulatory Guide 1.106 – "Thermal Overload Protection for Electrical Motors and Motor Operated Valves." The ESBWR does not require electric motors or motor operated valves to perform any safety-related function, therefore this regulatory guide is not applicable.

Regulatory Guide 1.118 — "Periodic Testing of Electric Power and Protection Systems." (See Subsection ~~8.3.4.2~~13.5.2 for Operating and Maintenance Procedures and Chapter 16 for Technical Specifications.)

Regulatory Guide 1.128 — "Installation Designs and Installation of Large Lead Storage Batteries for Nuclear Power Plants." The ESBWR Valve Regulated Lead Acid (VRLA) batteries ~~will~~ limit the release of hydrogen to less than 1% while battery room temperature is within specified vendor limits during charging evolutions. IEEE 344, IEEE 323, and IEEE 1187 apply to VRLA batteries. IEEE 484 is not applicable for VRLA batteries.

Regulatory Guide 1.129 — "Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Nuclear Power Plants." The ESBWR design allows for periodic testing, maintenance and replacement of batteries in accordance with IEEE 1188. IEEE 450 is not applicable for VRLA batteries.

Regulatory Guide 1.153 — "Criteria for Safety Systems."

Regulatory Guide 1.155 — "Station Blackout," The ESBWR uses battery power to achieve and maintain safe shutdown. Thus, the ESBWR meets the intent of Regulatory Guide 1.155. The Station Blackout evaluation is provided in Subsection 15.5.5.

Branch Technical Positions (BTPs):

BTP ICSB 21 — Supplemental Guidance for Bypass and Inoperable Status Indication for Engineered Safety Features Systems.

The DC power system is designed consistent with this criterion.

Other SRP Criteria:

Consistent with Table 8-1 of the SRP, there are no other criteria applicable to DC power systems.

8.3.3 Fire Protection of Cable Systems

The basic concept of fire protection for the cable system in the ESBWR design is that it is incorporated into the design and installation rather than added onto the systems. Fire protection is built into the system by cable separation; by limiting cable tray fill; by limiting cable ampacity to levels that prevent overheating and insulation failures (and resultant possibility of fire); and by use of fire resistant and non-propagating cable insulation. Fire suppression systems (e.g., automatic sprinkler systems) are provided as defined in Subsection 9.5.1.2. Further circuit analysis is provided in Section 9A.6.

8.3.3.1 Resistance of Cables to Combustion

The electrical cable insulation is designed to resist the onset of combustion by choice of insulation and jacket materials, which have flame-resistive and self-extinguishing characteristics. Polyvinyl chloride and neoprene cable insulation are not used in the ESBWR. Each power, control, and instrumentation cable is specified to pass the vertical tray flame test in accordance with IEEE 1202 (Reference 8.3-11). All cable trays are fabricated from noncombustible material.

8.3.3.2 Cables and Raceways

Power and control cables are specified for continuous operation at conductor temperature not exceeding 90°C (194°F) and to withstand an emergency overload temperature of up to 130°C (266°F) in accordance with ~~ICEA S-66-524/NEMA WC-7~~ICEA S-95-658/NEMA WC-70 (Reference 8.3-5)~~ Appendix D (conductors qualified to a higher temperature, such as 125°C may be used if local conditions require)~~. The base ampacity rating of the cables is established as published in IEEE 835 (Reference 8.3-6) and ICEA P-54-440/NEMA WC-51 (Reference 8.3-7).

Cables are specified to continue to operate at 100% relative humidity with a service life expectancy of 60 years. Safety-related cables are designed to survive the LOCA ambient condition at the end of the 60-year life span. Certified proof tests are performed on cables to demonstrate 60-year life, and resistance to radiation, flame, and the environment. ~~(r~~Refer to IEEE 383 (Reference~~s~~ 8.3-4) and ICEA S-95-658/NEMA WC-70 (Reference 8.3-5). The testing methodology ensures such attributes are acceptable for the 60-year life.

All cables specified for safety-related systems and circuits are moisture and radiation resistant, are highly flame resistant and evidence little corrosive effect when subjected to heat or flame, or both. Certified proof tests are performed on cable samples to:

- certify 60-year life by thermal aging;
- prove the radiation resistance by exposure of aged specimens to integrated dosage;
- prove mechanical/electrical tests of cable for environmental conditions specified;
- prove flame resistance by the vertical tray, 70,000 Btu/hr flame test for 20 minutes (minimum); and
- show acceptable levels of gas evolution by an acid gas generation test.

Cable tray fill is limited to 40% of the cross-sectional area for trays containing power cables; and 50% cross-sectional area for trays containing control and instrumentation cables. If tray fill exceeds the above maximum fills, the tray fill is justified and documented.

Cable splices in raceways are prohibited. Cable splices are only made in manholes, boxes or suitable fittings. Splices in cables passing through the containment penetration assemblies are made in terminal boxes located adjacent to the penetration assembly. (See Regulatory Guide 1.75 for splice exception.)

The cable installation is such that direct impingement of fire suppressant does not prevent safe reactor shutdown.

8.3.3.3 Localization of Fires

In the event of a fire, the installation design localizes the physical effects of the fire by preventing its spread to adjacent areas or to adjacent raceways of different divisions. Floors and walls are effectively used to provide vertical and horizontal fire-resistive separations between redundant cable divisions. Localization of the effect of fires on the electric system is accomplished by independence and separation of redundant cable/raceway systems and equipment as described in Subsection 8.3.1.4.

Three hour fire rated concrete barriers are used between the RATs, the UATs and the main transformers and spare main transformer as described in Subsection 9A.4.7, "Yard", and includes containment/collection of transformer oil.

In any given fire area, equipment is typically from only one safety-related division. This design objective is not always met due to other overriding design requirements. IEEE 384 (Reference 8.3-10) and Regulatory Guide 1.75 are always complied with, however. In addition, an analysis is made and documented in Appendix 9A to ascertain that the requirement of being able to safely shut down the plant with complete burnout of the fire area without recovery of the equipment is met. The fire detection, fire suppression, and fire containment systems provided, as described in Appendix 9A, assure that a fire of this magnitude does not occur.

8.3.4 COL Unit-Specific Information

None.

~~*8.3.4.1 Administrative Controls for Bus Grounding Circuit Breakers*~~

~~Bus grounding circuit breakers provide safety grounds during maintenance operations. Administrative controls are implemented via plant procedures (see Subsection 8.3.1.1.1).~~

~~*8.3.4.2 Periodic Testing of Power and Protection Systems*~~

~~The program for periodic testing of electric power and protection systems is in accordance with Regulatory Guide 1.118 and IEEE 338 (Reference 8.3-37) and is implemented via plant procedures.~~

~~*8.3.4.3 Regulatory Guide 1.160*~~

~~The Maintenance Rule Program is addressed within the programs section of the COL application.~~

8.3.5 References

8.3-1 IEEE 946, "Recommended Practice for the Design of ~~Safety-Related~~ DC Auxiliary Power Systems for ~~Nuclear Power~~ Generating Stations."

8.3-2 IEEE 485, "Recommended Practice for Sizing ~~Large~~ Lead-Acid ~~Storage~~ Batteries for ~~Nuclear Power Generating Stations~~Stationary Applications."

8.3-3 IEEE 535, "Standard for Qualification of Class 1E Lead Storage Batteries for Nuclear Power Generating Stations."

8.3-4 IEEE 383, “Standard for Type Test ofQualifying Class 1E Electric Cables, and Field Splices , and Connections for Nuclear Power Generating Stations.”

8.3-5 ICEA S-66-524/NEMA WC-7ICEA S-95-658/NEMA WC-70, “Cross-Linked Thermosetting Polyethylene Insulated Wire and Cable for the Transmission and Distribution of Electrical EnergyNonshielded 0-2kV Cables.”

8.3-6 IEEE 835, "Standard Power Cable Ampacity Tables."

8.3-7 ICEA P-54-440/NEMA WC-51, “Ampacities of Cables in Open-top Cable Trays.”

8.3-8 IEEE 1188, “Recommended Practice for Maintenance, Testing, and Replacement of Valve-Regulated Lead-Acid Batteries for Stationary Applications.”

8.3-9 IEEE 1187, “Recommended Practice for Installation Design and Installation of Valve-Regulated Lead-Acid Batteries for Stationary Applications.”

8.3-10 IEEE 384, “Standard Criteria for Independence of Class 1E Equipment and Circuits.”

8.3-11 IEEE 1202, “Standard for Flame-Propagation Testing of Cables for Use in Cable Tray in Industrial and Commercial OccupanciesWire and Cable.”

8.3-12 IEEE Standard C57.12.00, “Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers.”

8.3-13 IEEE 323, “Standard for Qualifying Class 1E Equipment for Nuclear Power Generatingon Stations.”

8.3-14 IEEE 344, “Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generatingon Stations.”

8.3-15 IEEE 519, “Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.”

8.3-16 IEEE 379, “Standard Application of the Single-Failure Criterion to Nuclear Power Generating Station Safety Systems.”

8.3-17 NEMA ICS-2, “Standards for Industrial Control Devices,and Systems: Controllers, and Assemblies Contactors, and Overload Relays Rated 600 Volts.”

8.3-18 Underwriter’s Laboratories Standard No. 845, “UL Standard for Safety for Motor Control Centers, 4TH Edition.”

8.3-19 IEEE C37.13, “Standard for Low Voltage AC Power Circuit Breakers Used in Enclosures.”

8.3-20 IEEE C37.16, “Preferred Ratings and Related Requirements for Low Voltage AC Power Circuit Breakers and AC Power CircuitService Protectors Preferred Ratings, Related Requirements, and Application Recommendations.”

8.3-21 IEEE C37.17, “American National Standard for Trip Devices for AC and General-Purpose DC Low Voltage Power Circuit Breakers.”

8.3-22 ANSI C37.50, “Test Procedures for Switchgear Low Voltage AC Power Circuit Breakers Used in Enclosures – Test Procedures.”

8.3-23 Underwriter's Laboratories Standard No. 489, "~~Branch Circuit and Service Circuit Breakers~~UL Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures."

8.3-24 NEMA AB-1, "Molded Case Circuit Breakers and Molded Case Switches."

8.3-25 IEEE C37.04, "Standard Rating Structure for AC High-Voltage~~Power~~ Circuit Breakers ~~Rating Structure~~Rated on a Symmetrical Current Basis."

8.3-26 IEEE C37.06, "AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis - Preferred Ratings~~ of Power Circuit Breakers~~ and Related Required Capabilities."

8.3-27 IEEE C37.09, "Standard Test Procedure for AC High-Voltage~~Power~~ Circuit Breakers Rated on a Symmetrical Current Basis."

8.3-28 IEEE C37.010, "Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis."

8.3-29 IEEE C37.11, "~~Power Circuit Breaker Control Requirements~~Standard Requirements for Electrical Control for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis."

8.3-30 IEEE C37.20, "Switchgear Assemblies and Metal-Enclosed Bus."

8.3-31 IEEE C37.20.2, "Standard for Metal-Clad Switchgear."

8.3-32 IEEE C37.100, "Standard Definitions for Power Switchgear."

~~8.3-33IEEE C57.12, "General Requirements for Distribution, Power, and Regulating Transformers."~~

8.3-33 IEEE 603, "Standard Criteria for Safety Systems for Nuclear Power Generating Stations."

8.3-34 IEEE C57.12.80, "Standard Terminology for Power and Distribution Transformers."

8.3-35 IEEE C57.12.90, "Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers."

8.3-36 IEEE C57.93, "Guide for Installation of Liquid-Immersed Power Transformers~~ (10 MVA and Larger, 69-287 kV rating)~~."

8.3-37 IEEE 338, "Standard Criteria for the Periodic Surveillance Testing of Nuclear Power Generating Station Safety Systems."

8.3-38 IEEE 308, "Standard Criteria for Class 1E Power Systems for Nuclear Power Generating Stations."

8.3-39 IEEE C37.013, "Standard for AC High-Voltage Generator Circuit Breakers Rated on a Symmetrical Current Basis."

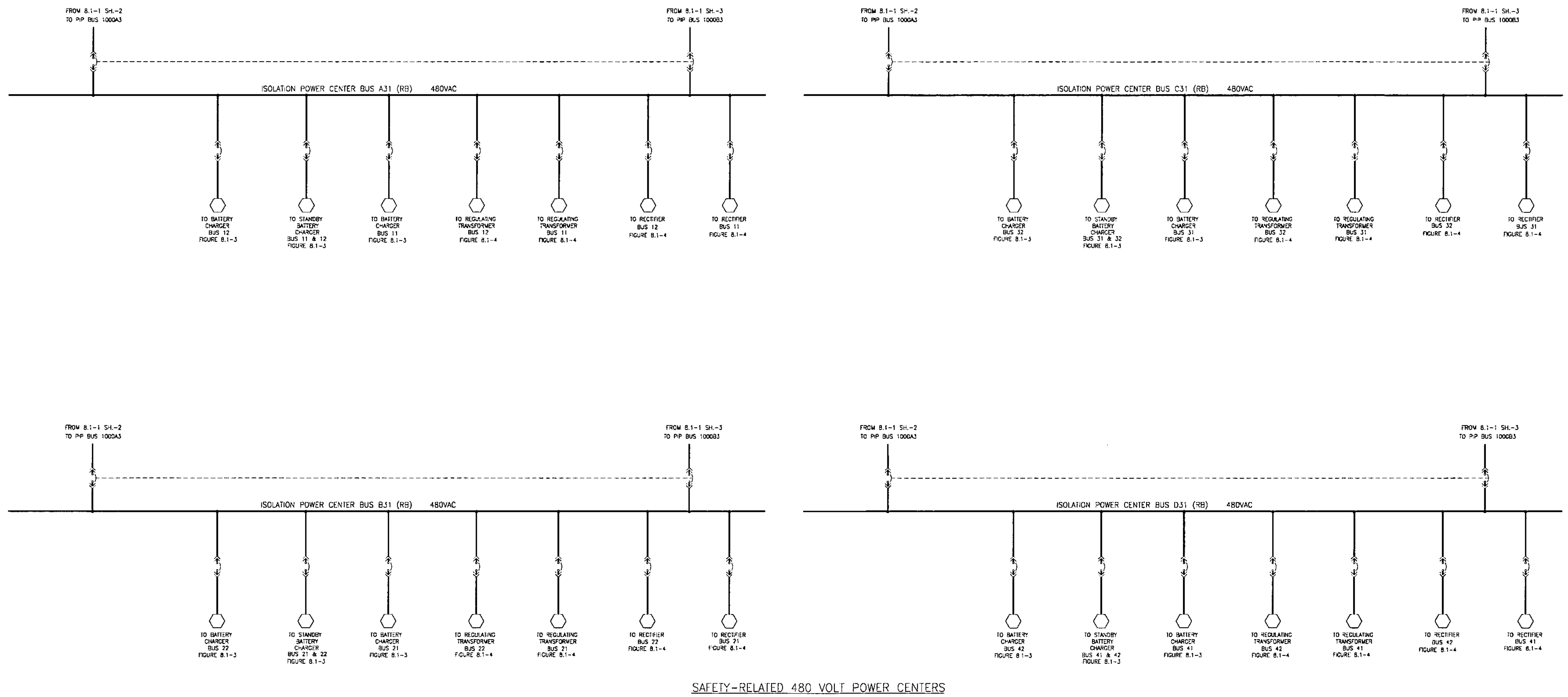

Figure 8.3-1. Safety-Related 480 Volt Power Centers

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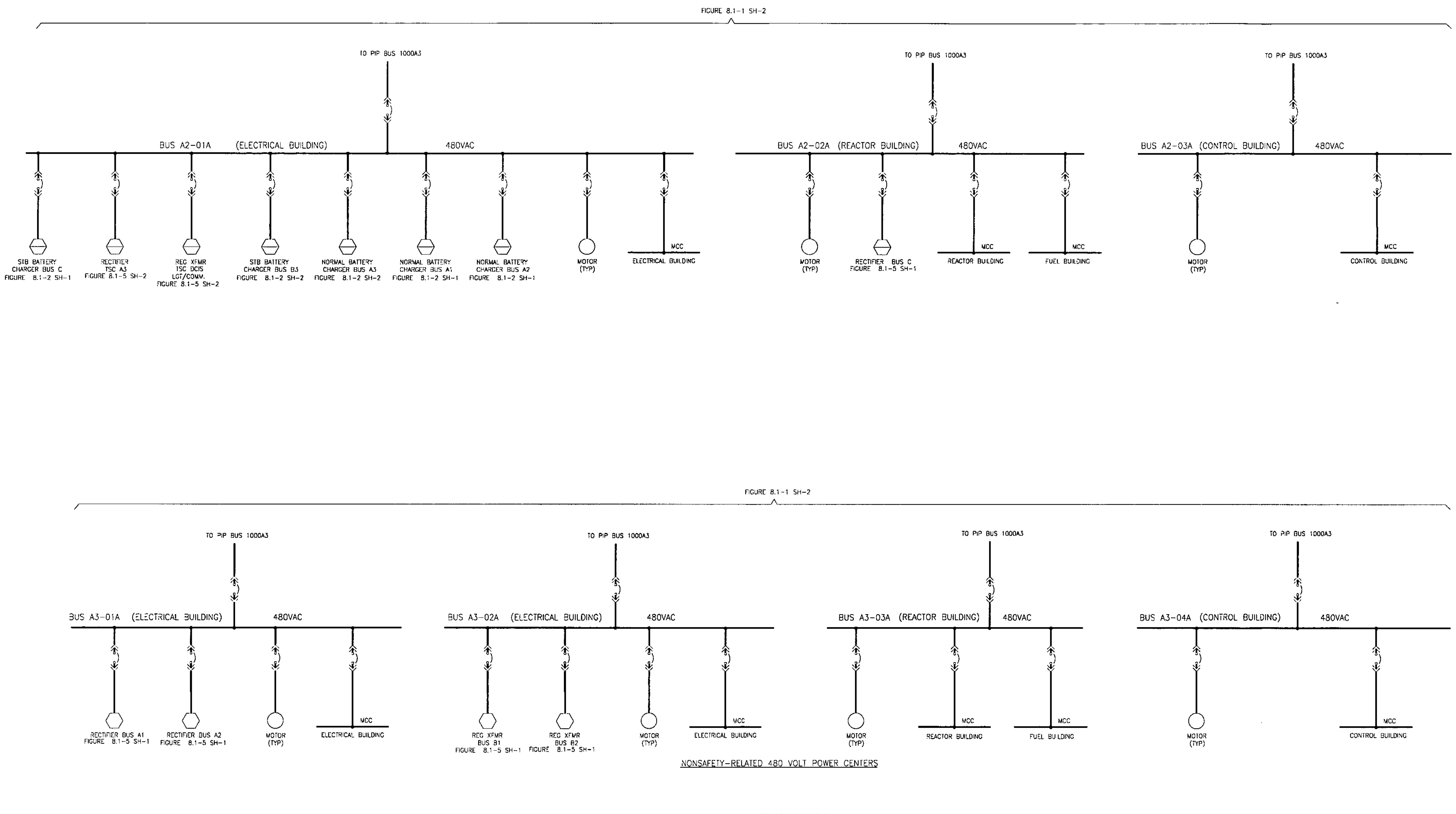

Figure 8.3-2~~1~~. Nonsafety-Related 480 Volt Power Centers
Sh 1~~2~~ of 34

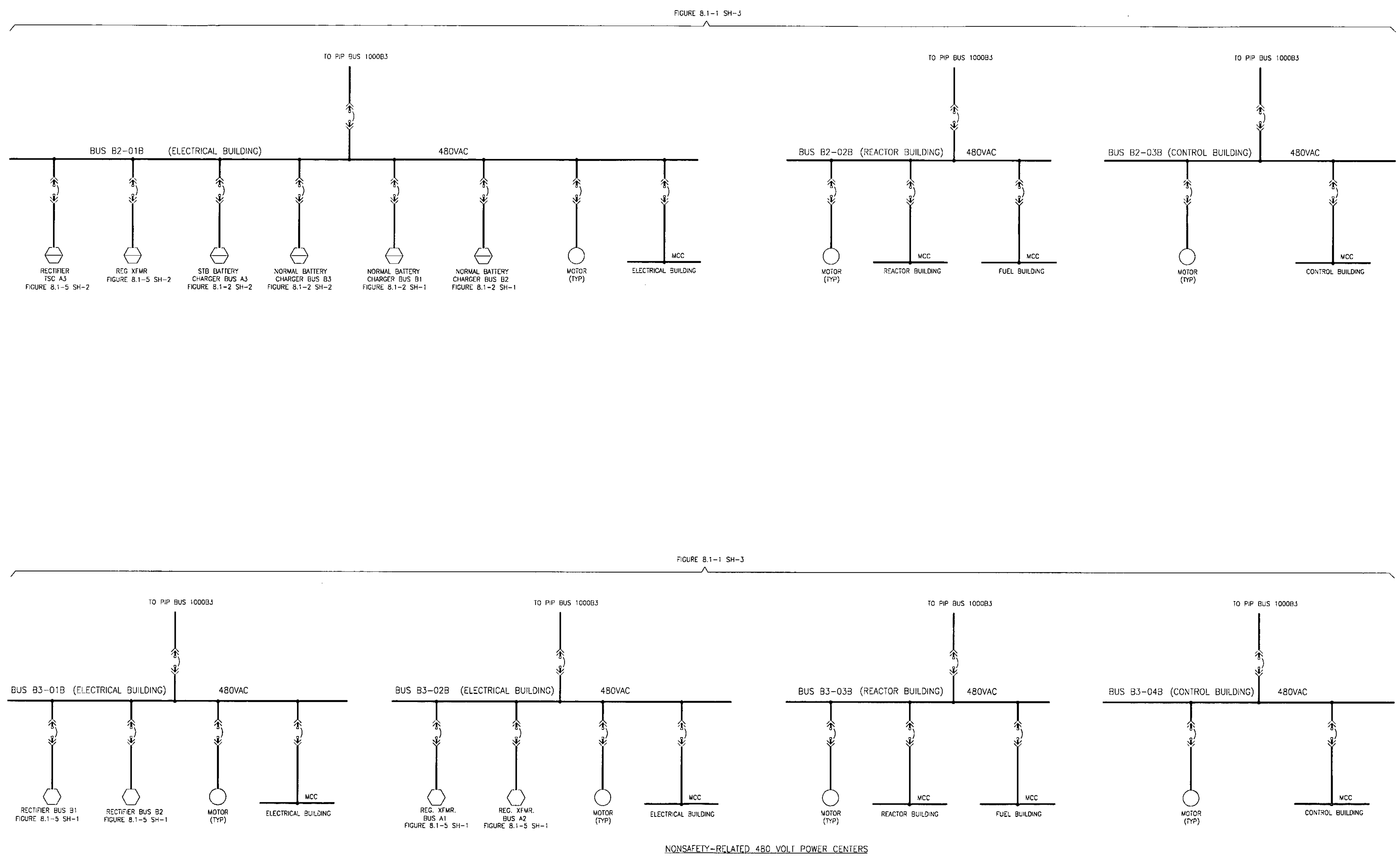

Figure 8.3-2~~1~~. Nonsafety-Related 480 Volt Power Centers

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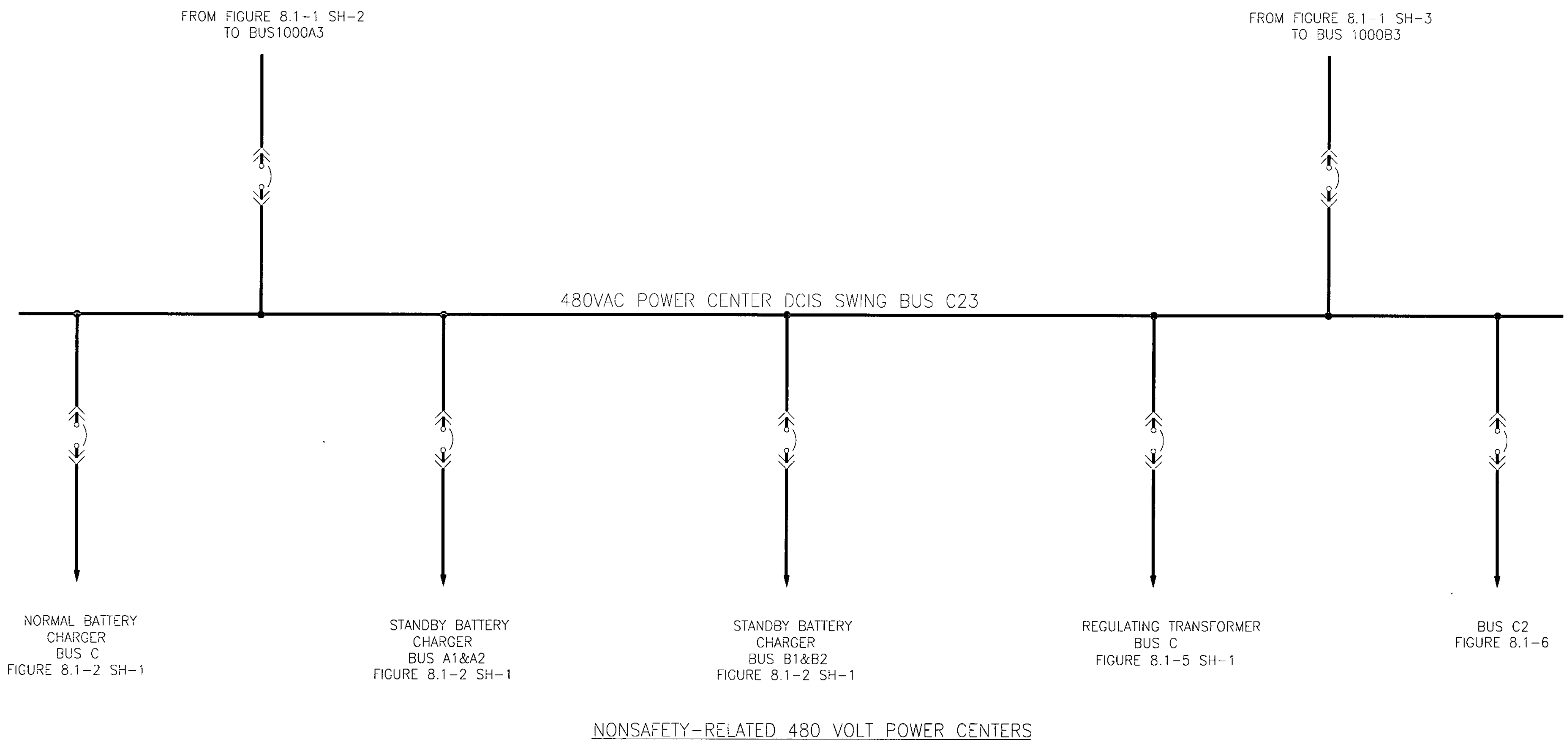

Figure 8.3-21. Nonsafety-Related 480 Volt Power Centers
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APPENDIX 8A MISCELLANEOUS ELECTRICAL SYSTEMS

8A.1 STATION GROUNDING AND SURGE PROTECTION

8A.1.1 Description

The electrical grounding system is comprised of:

- An instrument and computer grounding network;
- An equipment-grounding network for grounding electrical equipment (e.g., transformer, switchgear, motors, distribution panels, cables, etc.) and selected mechanical components (e.g., fuel tanks, chemical tanks, etc.);
- A plant grounding grid; and
- A lightning protection network for protection of all structures, transformers and equipment.

The plant instrumentation is grounded through a separate insulated radial grounding system comprised of buses and insulated cables. The instrumentation grounding systems are connected to the station-grounding grid at discrete points and are insulated from all other grounding circuits. Separate instrumentation grounding systems are provided for plant analog (i.e., relays, solenoids, etc.) and digital instrumentation systems. It should be recognized that there are numerous accepted grounding techniques and that the actual installation of a ground system should be made with reference to the recommendations of the I&C equipment manufacturers since the techniques used to solve one problem may result in the creation of a different problem (8A.4, References, 8A-8, IEEE-1050 "IEEE Guide for Instrumentation and Control Equipment Grounding in Generating Stations.").

The equipment-grounding network is such that all major equipment, structures and tanks are grounded with two diagonally opposite ground connections. The ground bus of all switchgear assemblies, motor control centers and control cabinets are connected to the station ground grid through at least two parallel paths. Bare copper risers are furnished for all underground electrical ducts and equipment, and for connections to the grounding systems within buildings. One bare copper cable is installed with each underground electrical duct run, and all metallic hardware in each manhole is connected to the cable.

A plant-grounding grid consisting of bare copper cables is provided to limit step and touch potentials to safe values under all fault conditions. The buried grid is located at the switchyard and connected to systems within the buildings by a 500 kcmil bare copper loop, which encircles each building.

Each building is equipped with grounding systems connected to the plant-grounding grid. As a minimum, every other steel column of the building perimeter is connected directly to the grounding grid.

The plant's main generator is grounded with a neutral grounding device to limit the magnitude of fault current due to a solid phase-to-ground fault. The impedance of the neutral grounding device limits the maximum phase-to-ground current under short-circuit conditions, however, it does not limit the current ~~to a value not greater than that~~ for a three-phase fault or phase-to-phase fault at its terminals.

8A.2 CATHODIC PROTECTION

8A.2.1 Description

A cathodic protection system is provided. Its design is plant unique and is tailored to the site conditions and meet the requirements listed in Subsection 8A.2.3.

8A.2.2 Analysis

There are no SRP or regulatory requirements nor any national standards for cathodic protection systems. The system is designed to the requirements listed in Subsection 8A.2.3.

8A.2.3 COL Unit Specific Information

The following provides the minimum requirements for the design of the cathodic protection systems. These requirements are the same as those called for in National Association of Corrosion Engineers (NACE) Standards (Reference 8A-5).

The need for cathodic protection on the entire site, portions of the site, or not at all shall be determined by site specific analyses. The analyses shall be based on soil resistivity readings, water chemistry data, and historical data from the site gathered from before commencement of site preparation to the completion of construction and startup.

(1) Where large protective currents are required, a shallow interconnected impressed current system consisting of packaged high silicon alloy anodes and transformer-rectifiers, shall normally be used. The rectifiers shall be approximately 50% oversized in anticipation of system growth and possible higher current consumption.

(2) The protected structures of the impressed current cathodic protection system shall be connected to the station-grounding grid.

(3) Localized sacrificial anode cathodic protection systems shall be used where required to supplement the impressed current cathodic protection system and protect surfaces which are not connected to the station-grounding grid or are located in outlying areas.

(4) Prepackaged zinc type reference electrodes shall be permanently installed near protected surfaces to provide a means of monitoring protection level by measuring potentials.

(5) Test stations above grade shall be installed throughout the station adjacent to the areas being protected for termination of test leads from protected structures and permanent reference electrodes.

8A.3 ELECTRIC HEAT TRACING

8A.3.1 Description

The electric heat tracing system provides freeze protection where required for outdoor service components and fluid warming of process fluids if required, either indoors or outdoors. If the operation of the heat tracing is required for proper operation of a safety-related system, the heat tracing for the safety-related system is required to be safety-related. Power for heat tracing is supplied from the ~~on-site~~onsite distribution system buses. Nonsafety-related heat tracing is supplied from the same Power Center or Motor Control Center as the components protected. Safety-related heat tracing is assigned to the appropriate division of safety-related power.